THE NATIONAL LABORATORIES OF THE UNITED KINGDOM, FRANCE, AND GERMANY IN TRANSITION: IMPLICATIONS FOR THE DEPARTMENT OF ENERGY LABORATORY SYSTEM

A Report Prepared under an Interagency Agreement
by the Federal Research Division,
Library of Congress

July 1994

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Federal Research Division
Library of Congress
Washington, DC 20540-5220

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave Blank*)

2. REPORT DATE

July 1994

3. REPORT TYPE AND DATES COVERED

Final

4. TITLE AND SUBTITLE

The National Laboratories of the United Kingdom, France, and Germany in Transition: Implications for the Department of Energy Laboratory System

5. FUNDING NUMBERS

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Federal Research Division
Library of Congress
Washington, DC 20540-5220

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Foreign Intelligence
U.S. Department of Energy
Washington, DC 20585

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Prepared under an Interagency Agreement

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

This study provides an overview of the national research systems of the United Kingdom, Germany, and France and makes relevant comparisons of research and development funding policies with the aim of determining whether those policies have any potential for further study and adoption by the United States.

14. SUBJECT TERMS

United Kingdom
France
Germany
Research and Development
Science and Technology

15. NUMBER OF PAGES

81

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std 239-18
298-102

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PREFACE

The United States Department of Energy (DOE) has tasked the Federal Research Division of the Library of Congress with providing an overview of the national research systems of the U.K., Germany, and France and to make relevant comparisons of R&D funding policies with the aim of determining whether those policies have any potential for further study and adoption in the U.S.

The research team has exploited the collections of the Library of Congress (including foreign language holdings in French and German) and it has contacted the science advisors of the respective embassies to collect relevant information concerning their national research systems and their current and future directions. The time frame of the study was from the mid-1980s to the present, with an emphasis on the most recent developments. The authors have studied the research policies, establishments, and institutional cultures of the target countries in an effort to provide a concise overview of the three systems for use by policy-makers.

EXECUTIVE SUMMARY

◆ The United Kingdom, Germany, and the United States are undergoing self-analysis and restructuring because of the unexpected and chaotic conclusion of the Cold War. The political, military, and economic changes that have created the current global economic and security climate have resulted in closer scrutiny of defense and "big science"-related budgets.

◆ Budget-tightening within the U.K., Germany, and France has had varying impacts on the national research systems of these countries because of their dissimilar structures, traditions, previous commitments, and economic expectations.

UNITED KINGDOM

◆ The U.K. has historically excelled in state-sponsored fundamental science, but has been less successful than its industrialized competitors in transforming key scientific discoveries into wealth-creating technologies. As a result, the public sector system of research and development has been tasked with supporting technology development as well as fundamental science.

◆ Under the Conservative government's "Next Steps" initiative, the British national laboratories have been disengaged from their parent government ministries and have been converted into government-owned contractor-operated organizations. At the same time, funding for intramural R&D has been steadily declining, forcing many of the applied sciences laboratories to scale down activities and reduce staff. In some cases, entire research agencies are being partially or fully privatized.

◆ Defense-related R&D accounts for 45 percent of all public sector R&D in the U.K., the largest share of military R&D expenditure in Europe. During the past five years, the U.K. has undertaken gradual reductions in overall defense expenditures, including defense-related R&D. Unlike in the United States, however, savings from defense R&D cutbacks are not being recycled into civil R&D programs, and development of "dual-use" technologies has not been emphasized.

◆ Government support for basic science has remained static in real terms, but is increasingly being diverted toward transnational collaborative science ventures within the European Union. As a result, fundamental research is becoming more internationalized, while national basic science facilities are reducing the scope of their activities.

◆ A recent review of national S&T policy restored government support for "near market" research, emphasizing the importance of developing key generic technologies considered vital to national technological competitiveness. The review reaffirmed the Conservative government's policy of establishing customer-contractor relationships between the central government and the national laboratories.

◆ In reconfiguring its research establishments, the British government has broadly curtailed the stable funding that previously supported laboratory-directed long-range research in the U.K. As a result, research in British national laboratories has become increasingly ad hoc and market oriented, with as yet undetermined consequences for the British national innovation system.

GERMANY

◆ The new Germany faces a period of financial and social recovery from the stresses of reunification and from ongoing integration into the European Union. Research facilities in the new eastern states have been included in the institutions receiving federal research money, diverting funds away from those facilities in the western states that had been awarded grants prior to reunification. Those western research institutions must now compete with the east for a smaller amount of federal money.

◆ There will be less funding for the established national research centers (GFEs) for several years. The nuclear energy laboratories at Juelich and Karlsruhe, in particular, are scheduled for reductions in support and redirection into technology transfer, environmental research, and applied areas of research.

◆ Recently, the BMFT Minister, Paul Krueger, was stung by criticism of the laboratories. An unpublished review solicited by the BMFT, and chaired by Daimler-Benz's head of research, recommended that the funds spent on applied research be increased from 30 percent to 75 percent of the current funding levels; that management at the centers be changed to a style more consistent with industry; and that industry have more of a say in the allocation of research funds.

◆ A radical redefinition of German S&T policy will no doubt be subject to compromise, and funding of basic research in the laboratories may increase as the essentially strong German economy recovers. The question remains, however, to what degree industry will prevail in its attempt to impose its short-term view of R&D on the culture of the GFEs. A major shift toward applied research will seriously handicap German research in the future by drawing funding away from basic research, the backbone of German industry.

◆ One part of the German national research system that has attracted the attention of policy-makers in the U.K. and the U.S. is the Fraunhofer Society. The Fraunhofer institutes are near-market, contract-based, research organizations that depend on the cheap labor of PhD students. Outsiders have viewed these institutes as a model of an effective, low-government-spending alternative to federally supported laboratories. A closer look reveals, however, that the institutes are actually heavily subsidized by the BMFT through indirect funding of contractors. This fact makes them an unsuitable model for adoption by the U.S. in an era of tight budgets. The U.K. recently abandoned the proposed Faraday Centres, its version of the Fraunhofer Society.

FRANCE

◆ The French research system, the descendant of a 300-year-old government, is highly centralized and relatively smooth functioning.

◆ The concentration of R&D in the Paris/Île-de-France region has been a concern for many years, and government officials have attempted to establish institutions outside Paris.

◆ French R&D is controlled and funded by two ministries: the Ministry of Research and Higher Education (MRES) and the Ministry of Defense (MoD). Parliament decides on the authorizations and appropriations, but much faster and with less debate than is true in the U.S. Congress.

◆ The CNRS (National Center for Scientific Research) resulted from the merger of three major institutions created after World War I. CNRS is subordinate to MRES. The CNRS, which has strong ties with the universities and the "Grandes écoles," it sets S&T policy, usually in the form of "Strategic Blueprints" that spell out government priorities and specific projects (domestic, the European Union, and international).

◆ The CNRS has been reconsidering its association with teaching institutions and it role as policy maker and policy promoter for its parent organization MRES because of funding problems.

◆ France is faced with threats to its standard of living from increasing unemployment, an aging population, and immigration from former colonies. France's self-image and drive to be a leader among nations are also important factors in its governmental R&D policy. A conflict appears to be emerging between national-interest goals and the need to address pressing social issues at home. These issues could impact R&D policy and funding. All these factors make it very difficult to make useful comparisons with the research system in the U.S. The 1995 elections may complicate the issues. A major shift in the ruling party could bring about major changes in R&D policy.
The French government currently is at an impasse with regard to funding its research institutions. Its historical traditions and institutional culture do not provide a useful model for imitation by the United States.

INTRODUCTION

The collapse of the Soviet Union brought an end to the Cold War and to the arms race between the superpowers. During a half-century of confrontation, the two sides were engaged in a technological race for military dominance. This competition forced both sides to spend significant amounts of their national budgets on defense research. One side-effect of the defense build-ups was that non-superpower countries had an opportunity to devote their budgets to commercial development, especially in the creation of effective technological infrastructures and gaining a larger share of world exports. This was particularly true of Germany and Japan.

Today, the former Cold War adversaries are undergoing perestroika, a complex restructuring of government institutions and socioeconomic systems. Part of the technological restructuring in the United States is the redirection of resources towards new goals, primarily efforts related to reducing costs and increasing global economic competitiveness.

An important characteristic of economic competition today is the portability of knowledge, technology, and sophisticated business skills that has made smaller players more able to compete in global markets. Brain drains, technological obsolescence (and the structural unemployment that accompanies it), attempts at foreign control of sensitive areas of research and development (R&D), the rise of multinational corporations without clear national loyalties, monopolization of entire technologies, and pressures to remove trade and legal barriers are some of the fallout from this increased portability. The end of the Cold War and the shift of a large share of economic power to Asia have had considerable impact on Europe and the United States.

These changes have made it essential for the countries undergoing their own restructuring to reevaluate their national priorities, in most cases with the aim of directing expenditures away from defense and toward commercial technologies. The United Kingdom, Germany, and France have begun to restructure their national laboratory systems with the aim of reducing government expenditures without sacrificing their technology base.

The U.S. Department of Energy (DOE) has determined that under these new world conditions and in an era of tighter federal R&D budgets, an analysis of foreign national research systems would be beneficial. Are these European nations making changes in their

national laboratory systems that could be applicable to the DOE laboratories? The purpose of the analysis is to identify and compare the structures of the major European national research systems with that of the U.S. and to identify any new policies that are being implemented, such as restructuring, new funding techniques, privatization, improved technology-transfer programs, and defense conversion of existing technologies. In short, any improvements that, if adopted, would have a positive impact on the efficiency and quality of federal R&D.

THE NATIONAL LABORATORY SYSTEM OF THE UNITED KINGDOM

Key Judgments

♦ The United Kingdom (U.K.) has historically excelled in state-sponsored fundamental science, but has been less successful than its industrialized competitors in transforming key scientific discoveries into wealth-creating technologies. As a result, the public sector system of research and development has been tasked to support technology development as well as fundamental science.

♦ Under the Conservative government's "Next Steps" initiative, the British national laboratories have been disengaged from their parent government ministries and have been converted into government-owned contractor-operated organizations. At the same time, funding for intramural R&D has been steadily declining, forcing many of the applied sciences laboratories to scale down activities and reduce staff. In some cases, entire research agencies are being partially or fully privatized.

♦ Defense related R&D accounts for 45 percent of all public sector R&D in the U.K., the largest share of military R&D expenditure in Europe. During the past five years, the U.K. has gradually reduced overall defense expenditures, including defense-related R&D. Unlike in the United States, however, savings from defense R&D cutbacks are not being recycled into civil R&D programs, and the development of "dual use" technologies has not been emphasized.

♦ Government support for basic science has remained static in real terms, but is increasingly being diverted toward transnational collaborative science ventures within the European Union. As a result, fundamental research is becoming more internationalized, while national basic science facilities are reducing the scope of their activities.

♦ A recent review of national S&T policy restored government support for "near market" research, emphasizing the importance of developing key generic technologies considered vital to national technological competitiveness. The review reaffirmed the Conservative government's policy of establishing customer-contractor relationships between the central government and the national laboratories.

♦ In reconfiguring its research establishments, the British government has broadly curtailed the stable funding that previously supported laboratory-directed long-range research in the U.K. As a result, research in British national laboratories has become increasingly ad hoc and market oriented, with as yet undetermined consequences for the British national innovation system.

History

Throughout most of this century, the British research system has been characterized by high levels of achievement in government-supported basic science, contrasted with a poor record of private sector investment in applied research and development. The U.K. has been at the forefront of several of the key scientific discoveries of the past fifty years, but has generally failed to transform its early experimental breakthroughs into wealth-creating technologies. A main preoccupation of the public sector system of research and development (R&D) has therefore been to balance traditional government support for fundamental science against a public sector responsibility to promote and catalyze national wealth creation. [1] **[64,15]**

Additionally, the U.K. is heavily dependent on science and technology to meet its defense obligations within the North Atlantic Treaty Organization (NATO) alliance. The British government devotes a large proportion of its R&D efforts to defense-related projects, spending almost as much on defense R&D as it does on civilian research. To this end, a network of Ministry of Defence (MoD) laboratories was established during and immediately following the Second World War to conduct applied research and experimental development of advanced conventional and unconventional weapons systems.[2]

The "Triad" of Government-Supported R&D

The mechanisms for state support of science and technology in the U.K. have been evolving since the end of the First World War. The basic components of the civil

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[1] In 1991-92, U.K. total spending on R&D was £11.9 billion (US$17.6 billion), or about 2.1 percent of Gross Domestic Product (GDP).**[26,9]** **[N.B. Rate of exchange: £1= $USD1.5]** Of this amount, approximately 58 percent was funded by the private and nonprofit sectors, while the remaining 42 percent was government-funded R&D. Government spending for R&D in 1991-92 totaled about £5.0 billion ($USD7.4 billion), representing 3.5 percent of central government expenditure and 0.88 percent of GDP.**[26,10]**

[2] In 1991-92, the single largest category of government R&D expenditure (39.4 percent) was experimental development--almost all of which was commissioned by MoD. The second largest proportion of government R&D spending (26.7 percent) was in basic research--all of which was funded by civilian agencies (primarily the Research Councils). Applied research accounts for the remaining 23.9 percent of R&D expenditure, with spending being about evenly divided between strategic and specific research activities. Applied research is commissioned both by civilian agencies and MoD.**[26,12]**

government R&D system originated during the interwar period, when direct state support for science and technology was instituted in response to the inability of universities to meet the rising costs of advanced scientific research. Concurrently, the British government opted to carry on the work of the state-run laboratories that had been established under emergency conditions during World War I to compensate for insufficient industrial investment in R&D. The defense R&D system was instituted shortly thereafter with the technological "crash" programs of the Second World War and the postwar armaments race. The current government-funded R&D system consists of a "triad" of R&D support networks within the Research Councils, the central government departments, and MoD.

Government spending on R&D is almost evenly divided between military and civilian programs, with military R&D representing 45 percent of total government R&D expenditure. [26,10] This amount is the largest share of military R&D expenditure in Europe, but is less than the 60 percent share devoted to military R&D in the United States. [44,49] Within the civil R&D budget, approximately two-thirds of spending is undertaken by the "science base," comprising the executive agencies responsible for basic science. The remaining one-third of civilian R&D is funded directly by the various civil departments. [26,10]

Research Councils and Higher Education Funding Councils

British government support for science is carried out by means of a "dual support" system for academic research. This system allows university-based researchers to obtain funding from two separate block grants administered by Research Councils and Higher Education Funding Councils (formerly the Universities Funding Council). The Research Councils and Higher Education Funding Councils are executive agencies of the central government, funded by block grants, and staffed by scientist-administrators. The Research Councils fund specific projects on the basis of peer review of grant proposals, while the Higher Education Funding Councils provide general funds directly to the universities to be used at the institutions' discretion. The dual support system is generally considered a successful model of support for basic research, although it has been weakened in recent years by sharp cuts in the budget of the Higher Education Funding Councils.

The Research Councils also administer directly a network of national science laboratories engaged in government-supported basic and strategic research. There are

currently six Research Councils channelling funds to universities and administering national laboratories: the Medical Research Council (MRC), the Biotechnology and Biological Sciences Research Council (BBSRC), the Economic and Social Research Council (ESRC), the Engineering and Physical Sciences Research Council (EPSRC), the Natural Environment Research Council (NERC), and the Particle Physics and Astronomy Research Council (PPARC).[3] [41,4]

Civil Department R&D

In addition to the Research Councils, the civil departments of the British central government also promote R&D by means of private contracts, and directly, by funding departmental laboratories. The civil government departments conduct applied research, mainly for purposes of policy support and industrial R&D support. Departmental R&D spending is dominated by two cabinet-level agencies: the Department of Trade and Industry (DTI), which includes the former Department of Energy, and the Ministry of Agriculture Fisheries and Food (MAFF). Together, these two agencies account for over half of the civil department R&D budget of approximately £1 billion (US$1.5 billion). [26,10] The remaining departmental R&D budget is distributed among a dozen other civil departments.

Ministry of Defence

The third leg in the triad of government support for R&D was spawned by the technological demands imposed on the British state by World War II. It consists mainly of MoD expenditure on defense R&D in private industry and in the Defence Research Agency (DRA). [29,71]

Overview of the National Laboratory System

The British national laboratory system has been the object of extensive reform under the Conservative government's "Next Steps" initiative, which seeks to improve the efficiency of state agencies by establishing customer-contractor relationships between the central government and its service units. The "Next Steps" program has brought profound change to

[3] In 1993-94, the Research Councils had a combined budget of £1.1 billion (US$1.6 billion) and the Higher Education Funding Councils were budgeted for £909 million (US$1.3 billion) for a total basic and strategic research budget of about £2 billion (US$3 billion), representing 71 percent of total civil R&D expenditure by government.[26,11]

the British national laboratories, which historically had been administered and funded directly by the central government. [28,44] Beginning in the mid-1980s, most of the national laboratories began to be systematically "disengaged" from the government ministries under which they had been established and were recast as quasi-independent government-owned contractor-operated organizations (GOCOs). Concurrently, an increasing share of central government R&D expenditure has been put out to tender for competitive bidding among both private and government-owned contractors.

Faced with the need to optimize their competitiveness in the new funding environment, the newly established research agencies that administer the national laboratories have sought to reduce operating costs by consolidating facilities and terminating research activities for which funding is no longer readily available. This has resulted in widespread decommissioning of "redundant" facilities and reductions in research staff, with as yet unknown long-term consequences for the British national innovation system.[2]

Civil Engineering and Physical Sciences Laboratories

The Department of Trade and Industry, the government department primarily responsible for technology transfer and applied research relating to industrial competitiveness, supports R&D by means of contracts with industry and other government agencies, as well as directly within its own extensive network of national laboratories. The DTI's applied sciences laboratory network has undergone extensive reorganization under the stewardship of DTI Minister, Michael Heseltine. [62,184]

Since the mid-1980s, most DTI-affiliated national laboratories have been separated from direct departmental control and have been converted into quasi-independent "Science and Technology Agencies." The largest single component of DTI to be thus disengaged was the United Kingdom Atomic Energy Authority (UKAEA), which was absorbed by DTI after the dissolution of the Department of Energy in 1988. [64,108]

As a network of government laboratories, the UKAEA had been responsible for all aspects of nuclear energy research and experimental development. It operated the single largest research facility in Europe, the massive laboratory complex at Harwell, which, at the height of its activity during the 1960s, employed 44,000 technical staff involved in a variety of programs, including thermal, breeder, and fusion reactor research, as well as nuclear

weapons and radioisotope experimental development. **[15,110]**

By the mid-1980s, UKAEA had spun off several of its activities to the MoD and the private sector, and was employing about 14,000 staff. In 1986, the Thatcher government directed UKAEA to deliver a return on capital in accordance with the prevailing political philosophy of government disengagement from "near market" research, necessitating further cuts in spending and a reduction in force to about 8,000. **[15,112]** In early 1990, nine government-owned business units were established, under the collective agency name of AEA Technology, to market UKAEA products and services. In March 1994, the government announced its intention to completely privatize the UKAEA by March 1995. **[61][1,7]**

The remaining DTI national laboratories are also undertaking a gradual disengagement from government ownership. Four major national laboratories engaged in applied physical sciences have already been transferred to cost-recovery status and are undertaking various streamlining measures to adjust to a more restrictive budgetary environment. The National Engineering Laboratory (NEL), the National Physical Laboratory (NPL), the Laboratory of the Government Chemist (LGC), and the National Weights and Measures Laboratory are the main centers for industrial measurement, testing, and calibration in the U.K. These facilities have all been transferred to cost recovery status since 1989 and are facing sharp budget cuts as a result of a general reduction in R&D contract funding by DTI. **[9][58]**

The engineering and physics laboratory of the Engineering and Physical Sciences Research Council (EPSRC), the Daresbury and Rutherford Appleton Laboratory (merged into a single laboratory in April 1994), is also scheduled to be transferred to contractor agency status by 1995. The EPSRC laboratory, oriented primarily toward the design and manufacture of scientific equipment for university laboratories, has an annual income of approximately £100 million (US$148 million). It currently plans to redirect up to one-fifth of its services toward industry, based on its capacity to market high power lasers, cryogenics equipment, geological and astronomical measurement equipment, and other scientific measurement devices. **[16]**

<u>Defense Laboratories</u>

The Defence Research Agency (DRA) was established in April 1991 as an executive agency under the Next Steps initiative. Its mission is to coordinate and market the R&D of

the four nonnuclear defense Research Establishments: the Royal Signals and Radar Establishment at Malvern--RSRE (now Electronics Division), the Royal Aerospace Establishment at Farnborough--RAE (now Aerospace Division), the Admiralty Research Establishment--ARE (now Maritime Division), and the Royal Armament Research and Development Establishment--RARDE (now Military Division).

Under the DRA's corporate plan, the Research Establishments continue to conduct mainly defense-related R&D, with about 90 percent of their work being financed by MoD contracts. The DRA, which has a budget of £400 million ($US592 million) and a staff of 12,000, performs about a third of all MoD contract R&D. **[52][26,15]** More than 90 percent of DRA research is on specific weapons systems, whereas only about 7 percent is strategic research. **[52]**

As in the U.S., the U.K. is undertaking gradual reductions in overall defense spending, including defense R&D expenditure. Current spending plans for defense indicate that a significant reduction is under way, with defense R&D expenditure for 1995-96 estimated to be one-fifth lower in real terms than in 1987-88. The government plans further reductions in defense spending of 15 percent over the next five years. **[35,50][30,18]**

The nonnuclear defense research establishments, reconfigured as GOCOs, now face a dual challenge to diversify within the context of competitive bidding among industry, the universities, and other laboratories. Since its formation, DRA has sought to "rationalize" its operations by shutting down facilities considered redundant and by consolidating the activities of laboratories spread out over more than 100 sites. Recent DRA cost-cutting efforts have included widespread downsizing of facilities and some research staff layoffs. **[35,50] [38,24]**

Particle Physics and Astronomy Laboratories

The national laboratories dedicated to basic research into particle physics and astronomy, funded by the Particle Physics and Astronomy Research Council, have been exempted from market style reforms, but have faced cutbacks within the context of greater internationalization of the U.K.'s science activities. Within the past several years, the U.K. has begun to shed its traditional reluctance to participate in transnational science projects, increasing its collaboration in pan-European programs such as the European Center for Nuclear Study and Research (Centre d'Etude et de Recherche Nucléaire--CERN) in Geneva,

the European Space Agency (ESA), and the Joint European Torus (JET) fusion research program. Spending on subscriptions to these organizations, which now represents 4 percent of government R&D spending, has begun to displace funding for national "big science" programs. [50,42]

As a result of budget limitations, the U.K. has begun to specialize in a reduced number of scientific activities, closing down facilities whose programs are duplicated elsewhere in Europe. The most recent and controversial such closure was that of the Nuclear Structure Facility (NSF) at Daresbury Laboratory, five years before the scheduled deactivation of its 20 Megavolt tandem Van de Graff accelerator. The NSF closure was justified by the forthcoming activation of the EUROGRAM, a similar pan-European facility in Strasbourg. [24,63]

Impact of Changes

The market-oriented reforms undertaken by the Conservative governments of Margaret Thatcher and John Major have had a profound impact on government support for science and technology in the U.K. The most dramatic changes have taken place in the area of intramural R&D, where the majority of government civil and defense laboratories, previously an integral part of their parent departments, have been disengaged and reconfigured as GOCOs. The conversion to GOCO status of most of the applied sciences research establishments has coincided with sharp cutbacks in the amount of funding, now made available through contracts, which the central government designates for its facilities. Concurrently, an increasing share of government R&D contract funding has been tendered for competitive bidding among the laboratories, industry, and the universities, thereby severing further the umbilical cord between government and its research establishments.[2][9]

As a result of the changes implemented by the Conservative administrations, the research establishments are no longer receiving the stable funding that previously supported departmental and laboratory-directed long-range research. Instead, many of the laboratories are now streamlining their activities, refocusing their research toward marketable and "dual use" products and services with potential clients in industry, academia, and overseas. The long-range implications of these changes for the British national innovation system are not yet fully apparent. Whereas government is hoping that large corporations will assume a

greater share of long-range research, British scientists and industry are lamenting the cutbacks and warning of irreparable damage to U.K. national competitiveness.**[59][55**,18-19]

Trends in R&D and the 1993 White Paper on Science and Technology

In May 1993, the British government's Office of Science and Technology, the central coordinating body for national S&T policy, published the White Paper, "Realising our Potential," on the future of the U.K. system of government support for national science and technology. **[28]** The White Paper, authored by the Minister for Science and Technology, William Waldegrave, was the result of a systematic review of the entire government R&D infrastructure. In preparing his report, the Science Minister adopted a consultative approach, soliciting proposals for reform of the government S&T support network from broad sectors of industry, academia, and government itself. The solicitation drew over 700 formal proposals for reform of the national S&T system. **[55]**

The final end product of the White Paper exercise was a brief report reaffirming most of the Conservative government's existing S&T policies and recommending modest changes in the current system of government R&D support. The White Paper resolved to reorient government's technology transfer efforts toward small businesses and away from larger corporations, recommending a return to "near market" R&D support for small and medium enterprises. The report also recommended that R&D support and technology transfer be centrally coordinated and focused on a few key "generic" technologies with strong prospects for future wealth creation. A "Technology Foresight" Steering Group would select a dozen key technologies in which future public sector investment would likely yield benefits for broad sectors of British industry. **[28**,19]

Addressing the issue of the national laboratories, the White Paper reaffirmed the government's commitment toward privatization of most of the applied sciences facilities, while assuming a continuing public sector responsibility for intramural basic research. **[28**,46] The report did not recommend additional funding for S&T support activities and did not address the issue of conversion of the national defense R&D laboratories.

The Future of the U.K. National Laboratories

The prevailing trends in British science and technology policy indicate that the reforms of the national laboratories being undertaken by the current government are likely to

continue without major modification. Most of the British applied sciences research establishments are now advancing toward privatization, although some facilities, such as DTI's standards and measurement laboratories, may be retained within the public sector because of their strategic importance as catalysts for national competitiveness.**[9]** The science laboratories of the Research Councils are the most likely to remain within the public sector indefinitely. The general trend, however, suggests an increasingly distant relationship between the government and most of the applied sciences national laboratories.

The reorganized laboratories will in many cases seek to diversify their activities in order to broaden their customer base. Conversely, the science laboratories that remain within the public sector will likely be required to specialize within certain subfields, as a greater share of funding for large-scale scientific projects is redirected toward transnational collaborative programs.

Comparison with the U.S Laboratory System

The significant differences in size, scope, and missions of the U.S. and British national laboratory systems limit the utility of any comparative analysis. In reconfiguring their research establishments, the British have, however, addressed several issues of relevance to the current U.S. national laboratory review.

The reforms of U.K. intramural R&D implemented by the last two Conservative governments introduced the same basic management principles that govern many of the U.S. national laboratories. The British have gone further, however, in disengaging their research establishments from government by expanding dramatically the competitive bidding process for government R&D contracts, and, in some cases, fully privatizing facilities. As a result, the British laboratories increasingly find themselves competing against industry, the universities, and other laboratories for contracts from their parent departments.

Perhaps of greater significance to the U.K. laboratories than the transfer to GOCO status has been the pronounced decline in government funding for intramural R&D. Whereas the U.S. is attempting to maintain stable funding for its civilian laboratories by transferring expenditure from defense to civil R&D, monies released by U.K. defense R&D cutbacks are not being recycled into the British civilian laboratories. Moreover, several of the British civilian laboratories are facing sharper cutbacks than are their defense counterparts.

These changes have meant an end to the type of stable funding that previously supported laboratory-directed and long- range research in the U.K., and an increasing reliance on Work-For-Others (WFO) activities among the British laboratories. The net effects of these changes have been to diffuse the laboratories' missions and introduce a bias toward short-term and potentially marketable types of research. Whereas the U.S. national laboratories have also moved in this direction, the U.S. has been more successful in preserving the primary and unique missions of its facilities, maintaining greater funding stability and placing statutory limits on WFOs.

The national laboratories for basic science in the U.S. and U.K. have historically been comparable in their roles and missions. During the past decade, however, British science has become increasingly internationalized--primarily within the framework of the European Union--whereas the U.S. has, until recently, maintained a national focus in its science megaprojects. The British experience in collaborating on transnational space research and high energy physics programs may yield valuable insights for U.S. participation in current and future collaborative science ventures.

SOURCES

1. "AEA Adapts to Compete in Changing Markets," Physics World [London], 6, No. 8, August 1993, 7-8.

2. Bown, William. "Competition Threatens British Labs," New Scientist [London], 138, No. 1870, April 24, 1993, 6.

3. ------. "Grand Designs for the Twenty-First Century," New Scientist [London], 135, No. 1838, September 12, 1992, 13-15.

4. ------. "Research Chiefs Fearful as Privatisation Looms," New Scientist [London], 138, No. 1877, June 12, 1993, 10.

5. ------. "Waldegrave's 'White Paper for Wealth'," New Scientist [London], 138, No. 1875, May 29, 1993, 4.

6. ------. "And Now, Here Is the Technology Forecast," New Scientist [London], 139, No. 1881, July 10, 1993, 12-13.

7. ------. "Secret Plans of Research 'Hit Squad'," New Scientist [London], 141, No. 1916, March 19, 1994, 8.

8. ------. "Union Threatens Injunction Over Warren Spring," New Scientist [London], 139, No. 1882, July 17, 1993, 10.

9. Bown, William, and Andy Coghlan. "'Bizarre' Plan in the Name of Efficiency as Privatisation Threatens Britain's Exports," New Scientist [London], 142, No. 1922, April 23, 1994, 4.

10. Campbell, Philip. "DTI Targets Small Companies and Greater Access," Physics World [London], 6, No, 7, July 1993, 5.

11. ------. "From Swords to Ploughshares, and Back," Physics World [London], 6, No. 3, March 1993, 13-14.

12. "Catalyst for Change," The Engineer [London], 275, No. 7127/8, November 26, 1992, 16-17.

13. Coghlan, Andy. "Britain Fails to Make Peaceful Use of Military Research," New Scientist [London], 130, No. 1773, June 15, 1991, 15.

14. Croft, Sally. "Axe Falls on Technology Transfer Lab," Physics World [London], 3, No. 9, September 1990, 5.

15. Currie, Ken. "British Lab Edges Toward Private Role," Forum for Applied Research and Public Policy, 8, Winter 1993, 110-14.

16. "Daresbury Laboratory: Preparing for a New Era of Enterprise," Chemistry & Industry [London], No. 20, October 18, 1993, 791.

17. Davies, Den. "Why HEIs Should Favor Defence Research," Physics World [London], 3, No. 2, February 1990, 15.

18. "Defence Jobs in Firing Line as Cuts Jeopardise R&D," New Scientist [London], 119, No. 1624, August 4, 1988, .

19. Dent, Carol. "Time to Join the Real World," New Scientist [London], 139, No. 1880, July 3, 1993, 42-43.

20. "End of an Era for Britain's Biggest Research Council," New Scientist [London], 138, No. 1874, May 22, 1993, 6.

21. "Foresight or Just Short Sight?," New Scientist [London], 138, 1876, June 5, 1993, 3.

22. "Funding 'Wedge' Threatens the Future of Big Science," Physics World [London], 6, No. 1, January 1993, 5.

23. Gavaghan, Helen. "Armed for Exploitation," New Scientist [London], 128, No. 1746, December 1990, 16-17.

24. Gelletly, Bill. "Nuclear Researchers Peer into the Abyss," Physics World [London], 6, No. 3, March 1993, 63-63.

25. Great Britain. Cabinet Office. Office of Public Service and Science. Advisory Council on Science and Technology. Defence R&D: A National Resource. London: HMSO, 1989.

26. ------. Cabinet Office. Office of Public Service and Science. Office of Science and Technology. Annual Review of Government Funded Research and Development, 1993: Summary. London: HMSO, 1993.

27. ------. Cabinet Office. Office of Public Service and Science. Office and Science and Technology. Annual Review of Government Funded Research and Development, 1989. London: HMSO, 1989.

28. ------. Cabinet Office. Office of Public Service and Science. Office of Science and Technology. Realising our Potential: A Strategy for Science, Engineering and Technology. London: HMSO, May 1993.

29. ------. Ministry of Defence. Statement on the Defence Estimates. Britain's Defence for the 90s. London: HMSO, 1991.

30. ------. Ministry of Defence. Statement on the Defence Estimates. Defence Statistics. London: HMSO, 1991.

31. "Greater Autonomy as NPL Sets New Standards," Physics World [London], 3, No. 7, July 1990, 7.

32. Gummett, Philip. "Recovering from the Cold War," New Scientist [London], 136, No. 1849, November 28, 1992, 21-23.

33. ------. "Threat-Driven Science," Physics World [London], 1, No. 8, November 1988, 21-23.

34. Gummett, Philip, and William Walker. "Science, Technology and the Peace Dividend," Physics World [London], 4, No. 1, January 1991, 29-32.

35. Hughes, Nigel, "The Future for the Defence Research Agency," RUSI Journal [London], 136, No. 3, Autumn 1991, 49-51.

36. Industrial Research in the United Kingdom: a directory of organizations and programmes. (14th ed.) London: Longman, 1992.

37. Jackson, Robert. "U.K. Research Policy," Science and Public Affairs [London], 4, No. 1, 1989, 51-55.

38. Kirkpatrick, D. L. "The Management of Defence Research," RUSI Journal [London], 137, No. 3, June 1992, 22-26.

39. Law, Sarah. "Fusion's Future in Europe," Physics World [London], 3, No. 10, October 1990, 13-14.

40. Lepkowski, Wil. "European Community Takes Bold New Steps in Science and Technology Policy," Chemical & Engineering News, 71, July 19, 1993, 9-17.

41. ------. "U.K. Research Structure: Government Plans Sweeping Reorganization," Chemical & Engineering News, 70, June 7, 1993, 4-5.

42. Macilwain, Colin. "Defence Spending on R&D Rockets Out of Control," The Engineer [London], 275, No. 7110, July 30, 1992, 8.

43. Mackenzie, Debora. "Battle Looms Over European Research," New Scientist [London], 133, No. 1812, March 14, 1992, 16-17.

44. Main Science and Technology Indicators, 1992. Paris: Organisation for Economic Co-operation and Development, 1992.

45. The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development. (4th ed.) Paris: Organisation for Economic Co-operation and Development, 1981.

46. Milne, Roger. "Dounreay closure jeopardises fast breeders," New Scientist [London], 135, No. 1834, August 15, 1992, 7.

47. "New Threats and Opportunities Emerge in UK Policy Changes," Physics World [London], 6, No. 7, July 1993, 4-5.

48. "Nuclear waste," Physics World [London], 6, No. 4, April 1993, 8.

49. Piccirelli, Annette (ed.). International Research Centers Directory, 1992-93. (6th ed.) Detroit: Gale Research, 1991.

50. Posner, Michael. "In Search of a Single Europe," New Scientist [London], 136, No. 1847, November 14, 1992, 40-42.

51. Rees, Martin. "Science-Driven Threats," Physics World [London], 1, No. 8, November 1988, 11.

52. Rodgers, Peter. "Defence Research: Agency's Troubled Birth," Physics World [London], 4, No. 4, April 1991, 6.

53. ------. "Physics at the Wedge of Chaos," Physics World [London], 6, No. 3, March 1993, 6.

54. Salter, Brian, and Ted Tapper. "The Application of Science and Scientific Autonomy in Great Britain: A Case Study of the Science and Engineering Research Council," Minerva [London], 31, No. 1, Spring 1993, 38-55.

55. "Science and Technology White Paper," Science in Parliament [London], June 1993, 50, No. 3, June 1993, 6-20.

56. Stone, T. A. "What Industry Can Do for Future Security," RUSI Journal [London], 136, No. 3, Autumn 1991, 52-56.

57. "Threats to measurement," Physics World [London], 6, No. 4, April 1993, 3.

58. "UK Industry Threatened by Cuts at National Physical Laboratory," Physics World [London], 6, No. 4, April 1993, 7.

59. "UK National Laboratories Face New Threat of Privatisation," Nature [London], 363, May 20, 1993, 196.

60. "UK Scientists Protest Lab Privatisations," Nature [London], 365, October 38, 1993, 778.

61. "UKAEA to Go Up for Sale," Physics World [London], 7, No. 3, March 1994, 15.

62. Walker, William. "National Innovation Systems: Britain," Pages 158-89 in Richard R. Nelson, ed. National Innovation Systems: A Comparative Analysis. New York: Oxford University Press, 1993.

63. "What Role for the NPL?," Physics World [London], 6, No. 3, March 1993, 65.

64. Wilkie, Tom. British Science and Politics since 1945. Oxford: Blackwell, 1991.

THE NATIONAL RESEARCH SYSTEM OF GERMANY

Key Judgments

◆ The new Germany faces a period of financial and social recovery from the stresses of reunification and from ongoing integration into the European Union. Federal research funds provided primarily by the Federal Ministry for Research and Technology (BMFT), have been shifted to the former East Germany, depleting resources that could have been used solely in the former West Germany.

◆ The established national research centers (GFEs) will receive less funding for several years. The nuclear energy laboratories at Juelich and Karlsruhe, in particular, are scheduled for reductions in support and redirection into technology transfer, environmental research, and more applied areas of research.

◆ Recently, the BMFT Minister, Paul Krueger, was stung by criticism of the laboratories. An unpublished review solicited by the BMFT that was chaired by Daimler-Benz's head of research recommended that the funds spent on applied research be increased from 30 percent to 75 percent of the current funding levels; that management at the centers be changed to a style more consistent with industry; and that industry should have more of a say in the allocation of research funds.

◆ Such a radical redefinition of German S&T policy will no doubt be subject to compromise, and funding of basic research in the laboratories may increase as the essentially strong German economy recovers. The question remains, however, to what degree industry will prevail in its attempt to impose its short-term view of R&D on the culture of the GFEs.

◆ One part of the German national research system that has attracted the attention of policy-makers in the U.K. and the U.S. is the Fraunhofer Society. The Fraunhofer institutes are near-market, contract-based, research organizations that depend on the cheap labor of PhD students. Outsiders have viewed these institutes as a model of an effective, low-government-spending alternative to federally supported laboratories. A closer look, however, reveals that the institutes are actually heavily subsidized by the BMFT through indirect funding of contractors. This fact makes them an unsuitable model for adoption by the U.S. in an era of tight budgets. The U.K. recently abandoned the proposed Faraday Centres, its version of the Fraunhofer Society.

History

Since World War II, Germans have enjoyed the benefits of low defense spending and a rising standard of living because of a growing market for their high-quality goods and services. German technology is based on the recovery of the scientific and technological infrastructure that was created in the nineteenth century when universities became centers for research and polytechnical schools (which eventually became the Technische Hochshulen) were established. At the beginning of the twentieth century, the government established some 40 to 50 institutes for specialized research in applied areas such as weather and atmosphere, geography and geology, health, shipbuilding, hydroengineering, biology, agriculture, fishery, and forestry. One of these institutes was the Imperial Institute of Physics and Technology, responsible for standards and measures. This institute was the model for the U.S. National Bureau of Standards, as well as for similar institutions in the U.K. and Japan. [**15**, 123-124] For a detailed review of the history of R&D in Germany, see Keck [**15**].

The Federal Ministry for Research and Technology (BMFT), currently a major S&T policy-maker, was originally established in 1955 as the Ministry for Atomic Questions. The BMFT is led by Paul Krueger, a PhD in mechanical engineering and former East German. Krueger replaced Mathias Wissman, who served only a few months after replacing Heinz Riesenhuber, who served as research minister for ten years. [**63**,7]

In 1990, the Bundestag Office of Technology Assessment (TAB) was established by the German Parliament along the lines of the US Office of Technology Assessment. TAB is seen as a competitor by the BMFT, which has ordered its own technology assessment research and has formed a joint agency with the Association of German Engineers (VDI). VDI administers the technology assessment projects for BMFT. [**51**,11]

Contemporary German science and technology policy envisions four major challenges:

- maintaining Germany's global competitiveness, particularly in the high-technology sector;
- furthering the development of the economic and political union of Europe, recognizing the importance of European R&D as a way of securing prosperity for all of Europe;

- aiding the Eastern European countries in the development of science and industry within democratic structures; and

- contributing to research on global problems such as energy and the environment (global warming, ozone depletion, tropical ecology), and foster sustained growth in the developing countries without progressive resource consumption. [10,16]

These challenges reflect the current attitudes of German society toward science and technology as the means for economic and social improvements, not as ends in themselves or as marks of national prestige, and are reflected in the often politically driven funding patterns of R&D. R&D is of central importance to the business sector: it is the fountainhead of innovative new products and processes that keeps German industry competitive.

Funding of R&D

The total research budget of Germany has doubled during the last decade from DM39.9 billion (US$26.6 billion) to DM80.7 billion (US$53.8 billion)[4]. As a percentage of GDP, however, the total research budget rose from 2.6 to 2.9 in 1987-1989, and declined to 2.6 in 1992. The number of R&D personnel grew from 352,897 to 474,900 during the same period. [10,61;65]

The primary sources (85-90 percent) of the total federal funding and their expenditure levels in 1993 (in DM billions) [10,67] out of a total expenditure of DM17.9 billion (US$11.9 billion) are:

◆ Federal Ministry for Research and Technology	(BMFT)	9.4 (US$6.26)
◆ Federal Ministry of Defense	(BMVg)	3.0 (US$2)
◆ Federal Ministry of Economics	(BMWi)	1.1 (US$.7)
◆ Federal Ministry of Education and Science	(BMBW)	2.0 (US$1.3)

For a comparison of trends over the period 1982-1993 and the relative contributions of the various ministries to R&D see Appendix, p.56)

The industrial portion of the total research budget of Germany as a percentage of the total R&D expenditure was 55.4 percent in 1981; the figure climbed to 63.3 percent in 1989 and declined to 58.9 percent in 1992. The absolute amount contributed in 1992 was more

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[4] US$1 = DM1.5.

than twice that contributed in 1981.

The proportion of R&D performed in the industrial sector and financed by industry itself in 1991 and 1992 was 85.8 percent. [10,60] See Appendix, p.57 for a breakdown of the total research budget by financing sectors.

Structure

The German Research System is organized into six components each with differing functions:

- Max Planck Society Institutes focus on independent basic research
- Fraunhofer Society Institutes focus on market-oriented research
- National Research Centers focus on large, complex interdisciplinary projects and are government laboratories
- University Research focuses on unified research and teaching
- Blue List of Independent Facilities perform research that is of supraregional importance and of national interest (100+institutions)
- Industrial Research (the total national R&D financed by the business sector was 58.9 percent in 1992)

R&D components receive funding from the federal government, the state governments (Länder), and industry. In general, the federal government funds the infrastructure of research that is beyond the means of the states, but the federal and state governments cooperate to promote scientific research that is of supraregional importance. [10,27] The states also fund the higher education sector. Industry funds the corporate research laboratories as well as research in universities and in other research organizations. (See Appendix, p.58)

Max Planck Society (MPG)

The institutes and research facilities connected with the Max Planck Society for the Advancement of the Sciences (MPG) are found in all parts of Germany. The former West Germany has 57 institutes with 62 research facilities and the former East Germany has 2 institutes with 39 research facilities.

The MPG focuses on basic research, with an emphasis on promising research areas

that are not suitable for university research because of their interdisciplinary nature or because of the high level of funding required. MPG Research projects are launched only if top talent can be recruited. Several MPG scientists are Nobel Prize winners. The MPG cooperates with universities and makes its large-scale equipment available to academic researchers. Genetic engineering is currently one area of such cooperation. [10,32]

Fraunhofer Society (FhG)

The federal and state governments provide joint sponsorship of the Fraunhofer Society (FhG) which is intimately involved with industry, primarily through contract research services that it provides to industry. [10,33] The FhG identifies the innovation potential of technologies at an early stage and provides industry with long-term contract research. Its structure lends itself to adaptation to new market requirements. The Society receives little direct government funding (however, indirect government funding is large) and must recover its costs from revenues obtained from contract research and other services.

National Research Centers

National Research Centers (GFEs) provide large-scale equipment for research (particle accelerators, research reactors, research vessels, and supercomputers), and management for dealing with sophisticated technological infrastructures.[10,32] The GFEs are comparable to the DOE Laboratories and have broad interdisciplinary capabilities, often collaborating with universities to manage national programs that contribute to international projects such as polar research, nuclear fusion research, and space research. The GFEs are also concerned with scientific environmental issues such as climate, atmosphere, water, contamination, and health research (molecular medicine and biotechnology). (See Appendix, p.59 for a complete directory of the National Research Centers.)

The GFEs and their associated laboratories were subjected to cuts in the 1993 budget; the BMFT increased funding to the Max Planck Institutes and the Fraunhofer Society. Recent changes in funding include cuts to the national research centers focusing on nuclear energy.[49,5] A summary of funding changes follows:

- Alfred-Wegener Institute for Polar & Marine Research +8.5%
- DESY Electron Synchrotron +5%
- GKSS cut by 1994
- GMD Math. & Computer Engineering 9% staff cuts; reduction from 14 to 8 institutes
- KFA Juelich and KfK Karlsruhe -2% in 1993 and -5% in 1995 Elimination of nuclear engineering

For more detailed information on funding of the National Research Centers over the period 1990-1992, see Appendix p.62. Despite cuts in nuclear research, the national research centers at Juelich and Karlsruhe and some Fraunhofer Society institutes are to receive some funding for research limited to the area of microsystems until 1997. Microsystems include the integration of sensor functions, signal processing, and actuator structures (miniaturized solid-state systems that may include mechanical, optical, chemical, or biological functions). The work is to be done jointly with industry, a new funding mechanism being used by the BMFT.

University Research

In 1991, the German Science Council (Wissenshaftsrat, an advisory body to the Federal and State governments on academic research) noted that government funding for non-university research institutions had expanded over the last decade while universities saw no increase in funding. The lack of increased funding, together with the concomitant rise in enrollments, has led to the loss of research competitiveness. The Council concluded that a consequence of this condition would be the establishment of institutes outside the universities, damaging the important link between research and teaching. The Council, therefore, recommended that external funding be made available by the German Research Foundation, the largest provider of such funding, and the BMFT.

Universities are also closely associated with the GFEs which provide access to large-scale equipment and joint appointments for professors at the Research Centers. [10,29] The German Research Foundation (DFG), which is itself funded by the Federal and State

governments, had a budget of DM1500.8 millions (US$1.5 billion) in 1992. See Appendix, p.64 for a breakdown of the programs under the DFG and for its relative position in the national research funding system.

The university system will undergo considerable change in the 1990s as nearly half of the current faculty and a third of the scientists retire, making room for younger faculty and scientists. [10,34] Not all is well in the universities: the German Science Council has found them to be overly bureaucratic, inefficient, and lacking in purpose and vision. The head of the Science Council has pronounced the system "rotten" and in need of "revision at the foundation." [45,9].

Blue List Institutes (BLI)

The "Blue List" consists of institutions (BLIs) that do not fit into the traditional categories. The term originated from an annex to a research institution funding agreement in 1975 that was printed on blue paper. Thirty-four institutions in the new eastern states have recently been added to the original 48 West German institutes. [10,33] These institutions and their host states identify important areas of supraregional research and have considerable impact on federal research policy. They are funded equally by the federal and state governments. The Blue List institutions are organized into eight sections: humanities and social sciences, economic sciences, education sciences, medicine, biology and other natural sciences, information and documentation, and the research activities of museums.[10,33] The growth of the Blue List Institutes has drawn strong criticism from the universities who see them as direct competitors for funding.[60,9]

Reunification

In the recent post-Cold War period, the former West Germany has been faced with the challenge of reunifying with the former East Germany. Despite being hailed as one of the "success stories" of the former communist world (having the highest per capita GNP of all socialist countries), East Germany's standard of living and quality of goods were very low when compared with the West.[13,226] The combination of economic recession and reunification has burdened the German economy, negatively impacting federal and state research and technology planning and funding. Privatization plans under the administration of the Treuhand-Ansalt (THA), an independent board of trustees, has not been very

successful: only 9 of 117 research companies have proved viable. [53,11]

The extent of the economic problems for R&D in the eastern states can be appreciated best from employment statistics. Since 1989, employment has declined from 3.6 million to 750,000, and among R&D workers it has declined from 75,000 to just 1500. (See Appendix, p.65)

Following the recommendations of the Science Council, the BMFT, which accounts for about 50 percent of total Federal R&D spending, has committed itself to the support of the restructured research institutions in the eastern states in the following R&D areas: new environmental technology, production engineering, renewable energy and energy conservation, basic information technologies, space technology, materials research and ground transport. (See Appendix, p.66) The objectives of the 1992 funding (DM607.4 million/US$404.9 million) were to increase technological competitiveness, promote new technology firms, build up and strengthen small- and medium-sized enterprises, and develop the R&D supporting infrastructure in the eastern states.

Global Competition and R&D

"In 1988, West Germany, with a population of 61 million, exported goods having a total value of $323 billion, about the same as the United States ($320 billion), and more than Japan ($265 billion). On a per capita basis, this is 4.0 times more than the United States and 2.4 more than Japan." [15,115] Some of the factors contributing to Germany's economic success since World War II are its strong banking system, rapid adoption of technology from abroad, an educational and research system geared to technical knowledge and skills, continuity in the business sector, its traditional strengths in the chemical and machine construction industries, European trade protection, and the diversified high-quality products that are the primary German exports. See Appendix, p.68 for a list of the 25 largest German manufacturing companies. More than half of these companies were established before 1913 and survived the World Wars.

Germany's recovery after World War II was handicapped by the Allied imposition of a prohibition on R&D in military technology and in some areas of civilian technology, including nuclear, aeronautical, rocket propulsion, radar, and remote and automatic control. Exceptions were required before work could be done or such items as electronic valves, ball

and roller bearings, synthetic rubber, synthetic oil, and radioactivity other than for medical purposes. The prohibition continued until 1955 when the Federal Republic became a sovereign state. This prohibition is given as the major reason for the relatively poor export performance of the German aircraft, electronics, and telecommunication industries. [15,136]

Germany's industrial sector both funds and performs most of the national R&D. The Federal government has generally followed a hands-off policy with respect to markets and industry. Basic research has done very well under this system, enjoying a 20 percent share of R&D expenditures by government and industry compared to 12 percent in the US and 13 percent in Japan. [10,13]

Because of Germany's relatively protected market within Europe, there is concern that liberalization of that market will lead to strong competition, especially from the Japanese. In order to prevent monopolization of any technology or market, Germany will seek to increase cooperation on R&D with the U.S.

Energy and the Environment

Germany's Third Program on energy research was approved in 1990, before reunification, and continues through 1995. The five objectives of the program are to further develop existing energy sources, find new carbon dioxide-free energy sources, seek efficient energy conversion and conservation technologies, develop energy sources that reduce noxious gases, and guarantee the energy supply in the future without damaging the environment. [68,393] Nuclear energy currently supplies the eastern states with about 40 percent of its power. Once the dominant factor in energy R&D, nuclear energy has declined. It remains to be seen, however, if this decline can continue and still meet German national objectives.

Priorities for the future promotion of nuclear energy research and development are:

- reactor safety research as a preventive measure ensuring the highest possible degree of safety;
- radiation protection (for which the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is responsible) for protecting the population from the adverse effects of ionizing radiation;
- international safeguards preventing any abusive diversion of fissile material;
- dismantling of nuclear facilities;

- supportive measures, above all concerning the safety of nuclear fuel cycle systems;
- waste disposal;
- advanced reactor systems, including scientific support concerning the safety of the SNR 300 and the future breeder reactor, high-temperature reactors, and scientific support for the safety of new reactor concepts. [68,396]

For a breakdown of expenditures on energy research from 1984-1989 and 1990-1993 see Appendix, p.69. In 1993, the total Federal R&D expenditure on energy research was DM1,127.2 millions (US$751.5 million), of which DM454.9 million (US$303.3 million) was for nuclear energy research, DM9.7 million (US$6.5 million) was for decommissioning of nuclear facilities, and DM206.1 million (US$137.4 million) was for nuclear fusion research. (See Appendix, p70.)

The general public attitude toward nuclear energy and nuclear weapons in Germany tends to be negative. The German Green Party is part of a small but enduring movement whose success, in part, derives from federal funds for which it qualifies whenever it receives 0.5 percent of the vote in national elections. [30,8] The Green movement is a highly fragmented phenomenon, with many internal conflicts between the left and right wings. Some view the actions of the various groups as democracy in action. The fruits of engaging in energy politics were changes in public policy leading to the introduction of new plant and pollution control technologies and the undermining of the legitimacy of bureaucratic experts. [11,46] It is unlikely, however, that the Greens will prevail against the pressure of the growing demand for energy in Germany and Europe as a whole. If, as a consequence of the protests, nuclear reactor design and control become safer, then the movement will have served a purpose.

EU and Its Impact on R&D

In addition to reunification, Germany has recently undergone a second major integrative process: unification with the European Community, (now the European Union [EU]). Germany has cooperated with the EU on many projects: ESA, CERN, EMBL, ESO, large-scale facilities such as the ILL Very-High-Flux Reactor, the European Synchrotron Radiation Facility (ESRF) in Grenoble, France and the European Transonic Wind Tunnel

(ETW) in Cologne, Germany. [10,16] In addition, the Eureka initiative, which provides seed money for technology development, has generated 550 projects since 1985 and has been very successful at encouraging cross-border research. The Eureka program, established in 1985 to provide seed money to small- and medium-sized firms, is based on shared risks and complementary technological capabilities. [22, 312]

The primary EU-sponsored R&D effort is the Framework Program, which combines and coordinates the resources of EU members in critical areas of science and technology. The goal is to foster pre-competitive technology development while avoiding duplication of effort. [22,315] Previous frameworks (I-III) included ESPRIT, RACE, EURAM, and BRITE. (For a partial summary of past Frameworks see Appendix, p71.) See Appendix, p.72 for Framework IV, which would provide about $15.7 billion over the period 1994-1998. Frameworks are based on the principle of subsidiarity: "The EU should do nothing that the individual countries can do as well by themselves." [19,10] This principle permits easier agreement for joint efforts, but true integration of European R&D may be more difficult to achieve.

The EU approach, with its large multinational funding, has many critics in Europe. It is seen as highly politicized, prone to delays, overly bureaucratic and frequently unfair, especially in its refereeing of grant applications. [1,461] For a survey of the literature on the economic effects of EU integrations see Ohly [25].

Comparison with the United States Laboratory System

What lessons can be drawn from this brief study of the German research system that might be of potential value to the U.S. research system?

The structures of these two systems differ in that there is no U.S. equivalent to the BMFT or to the Fraunhofer Institutes. They are similar in that the prominent National Research Centers are similar to the laboratories of the Department of Energy, but without nuclear weapons research [64,160]. Like the DOE laboratories, nuclear energy in Germany is experiencing a decline in funding for social, political, and economic reasons.

In Germany, one gets the impression that, with the possible exception of the Max Planck Institutes, all R&D must be aimed at the bottom line. Although this may not be

strictly true, the public and industry have strongly criticized many of the R&D institutions as well as universities and their programs for a perceived lack of contribution to economic competitiveness and overconcern with national prestige. Space policy, in particular, has been the focus of criticism from both the public and parts of the scientific community. [37,6].

A review panel of scientists, chaired by a physicist, and comprising 14 outstanding scientists, including Nobel prize winners, has called for putting limits on big science and increasing the emphasis on the life sciences--a policy that would have a negative impact on the National Research Centers, although their important and valid role in long-term, large-team, and large-scale research is acknowledged. [45,8]

Near-market research and faster recognition and development of products is the province of the Fraunhofer Society and its institutes, which have been described as "a nursery for high-powered technologically literate business people" and as more akin to providing medical training than in producing engineering postdoctoral candidates. [6,25] The U.K. has dropped its intention to create the "Faraday Centres" on the Fraunhofer model, giving the reason that the same objectives can be met by extending the operation of existing initiatives and schemes.

Actually, it has been shown (See Appendix, p.73) that the Fraunhofer Society model, which enjoys a good reputation and is at first glance so appealing because 70 percent of funding is derived from contract work for industry, is actually 80 percent subsidized by the German taxpayer. Most of the contract funds can be traced back to their source, the BMFT.

How is U.S. research viewed by a member of the Fraunhofer Society? Hariolf Grupp, in an interview with the IEEE, puts the U.S. at the forefront of research, primarily because of the eminent scientists that left Europe during World War II. He believes, however, that the U.S. "lacks a national technology policy and the equivalent of a Federal R&D ministry," and that "as long as all competitors pursue decisive technology policies, America is lost with its approach." Grupp sees U.S. research pre-eminence declining and being replaced by globally oriented research. He does not see Japan or Asia as convincing challengers because of rigid social systems. "For creative R&D activities, conformism and social underdevelopment are poison." [14,79-80]

SOURCES

1. Anderson, Alun. "U.S. Juggernaut Overwhelms Divided European Elite," Science, 2556, April 24, 1992, 460-64.

2. Archibugi, Daniele, and Mario Pianta. "Patterns of Technological Specialisation and Growth of Innovative Activities in Advanced Countries." Pages 105-32 in Kirsty S. Hughes (ed.). European Competitiveness. Cambridge: Cambridge University Press, 1993.

3. Bown, William. "German Innovation, British Imitation," New Scientist [London], 135, November 21, 1992, 12-13.

4. Campbell, Philip. "Collaborative Irritants," Physics World [London], 4, No. 7, July 1991, 3.

5. ------. "Framework Heads for Strasbourg," Physics World [London], 7, No. 1, January 1994, 10.

6. Coghlan, Andy. "Revolt of the Industrialists," New Scientist [London], 136, October 31, 1992, 23-25.

7. Dickson, David. "An Entrepreneurial Tree Sprouts in Europe," Science, 245, September 8, 1989, 1038-40.

8. Dunning, John H. "Multinational Enterprises and the Globalization of Innovatory Capacity," Research Policy, 23, January 1994, 67-88.

9. Enabling the Future: Linking Science and Technology to Societal Goals. New York: Carnegie Commission on Science, Technology, and Government, September 1992.

10. Germany. Federal Ministry for Research and Technology. Report of the Federal Government on Research, 1993. (Abridged.) Bonn: 1993.

11. Hager, Carol J. "Democratizing Technology: Citizen and State in West German Energy Politics, 1974-1990," Polity, 25, No. 1, Fall 1992, 45-70.

12. Hughes, Kirsty. "The Role of Technology, Competition and Skill in European Competitiveness." Pages 133-57 in Kirsty S. Hughes (ed.). European Competitiveness. Cambridge: Cambridge University Press, 1993.

13. Kaltenhalter, Karl, and Christopher Anderson. "The Domestic Politics of the Post-Unification Era: Politics, History, and Economy." Pages 225-42 in C. Anderson, et al. (eds.). The Domestic Politics of German Unification. Boulder, Colorado: Lynne Rienner, 1993.

14. Kaplan, Gadi, and Alfred Rosenblatt. "The Expanding World of R&D," IEEE Spectrum, October 1990, 28-33.

15. Keck, Otto. "The National System for Technical Innovation in Germany." Pages 115-57 in Richard R. Nelson (ed.). National Innovation Systems: A Comparative Analysis. Oxford: Oxford University Press, 1993.

16. Kenward, Michael. "British Innovation, German Style," New Scientist [London], 133, March 21, 1992, 17-18.

17. Kienle, Paul. "Why Nuclear Physics Must Survive," Physics World [London], 6, March 1993, 17-18.

18. Layman, Patricia L. "Advances in Feedstock Recycling Offer Help with Plastic Waste," Chemical & Engineering News, 71, October 4, 1993, 11-14.

19. Lepkowski, Wil. "European Community Takes Bold New Steps in Science and Technology Policy," Chemical & Engineering News, 71, July 19, 1993, 9-17.

20. Maier-Leibnitz, Heinz, and Christoph Schneider. "The Status of Academic Research in the Federal German Republic: A Report on Two Surveys and the Testimony of Individual Scientists," Minerva [London], 29, Spring 1991, 28-60.

21. Mariani, Jean-François. "Europe and Japan: Same Game, Different Rules," Physics World [London], 4, September 1991, 18-20.

22. McLoughlin, Glenn J. Europe and the United States: Competition and Cooperation in the 1990s.(Study papers submitted to United States Congress, House of Representatives. Committee on Foreign Affairs. Subcommittee on International Economic Policy and Trade. Washington: GPO, 1992.

23. "Minister seeks more R&D dialogue," R&D Magazine, May 1993, 21-22.

24. Nelson, Richard R. "A Retrospective." Pages 505-23 in Richard R. Nelson (ed.). National Innovation Systems: A Comparative Analysis. Oxford: Oxford University Press, 1993.

25. Ohly, Claudia. What Have We Learned About the Economic Effects of EC Integration? Commission of the European Communities. Directorate-General for Economic and Financial Affairs, September 1993.

26. Paterson, William E. "Germany in Europe." Pages 165-84 in Jonathan Story (ed.). The New Europe. Oxford: Blackwell, 1993.

27. Pedersen, Tor. "Europe's New Reactors," Physics World [London], 4, No. 8, August 1991, 37-40.

28. Rizutto, Carlo. "Funding Basic Science in the EC," Physics World [London], 6, No. 9, September 1993, 37-39.

29. Rodgers, Peter. "ILL Neutrons Stopped Until 1994," Physics World [London], 4, No. 8, August 1991, 7.

30. Ruedig, Wolfgang. "Green Party Politics," Environment, October 1991, 7-9, 25-31.

31 Schapira, Jean-Paul. "'Electrical Breeder' Fuels Nuclear Debate," Physics World [London], 7, No. 1, January 1994, 24-25.

32. Schneider, Fritz. "Germany Nurtures Trust Between Industry and Students," Physics World [London], 5, No. 4, April 1992, 57-58.

33. Science and Technology Agenda for the Nation: Recommendations for the President and Congress. New York: Carnegie Commission on Science, Technology, and Government, December 1992.

34. Science, Technology, and Congress: Organizational and Procedural Reforms. New York: Carnegie Commission on Science, Technology, and Government, February 1994.

35. Seibel, Wolfgang. "Necessary Illusions: The Transformation of Governance Structures in the New Germany." Pages 117-34 in C. Anderson et. al. (eds.). The Domestic Politics of German Unification. Boulder, Colorado: Lynne Rienner, 1993.

36. Sietmann, Richard. "Eastern Germany's Physics: Constraints on a Friendly Take-over," Physics World [London], 4, No. 1, January 1991, 13-14.

37. ------. "Germans Slam Manned Programmes," Physics World [London], 4, No. 2, February 1991, 6.

38. ------. "Germans Face Budget Cuts," Physics World [London], 4, No. 4, April 1991, 9.

39. ------. "Germany's Industrial R&D in Jeopardy," Physics World [London], 4, No. 5, May 1991, 5.

40. ------. "Max Planck Goes East," Physics World [London], 4, No. 5, May 1991, 6-7.

41. ------. "German Spending Precipitates Space Shortage," Physics World [London], 4, No. 8, August 1991, 11.

42. ------. "All Change at the Academy," Physics World [London], 4, No. 8, August 1991, 12-13.

43. ------. "German Nuclear Cloud Has Silver Lining," Physics World [London], 4, No. 9, September 1991, 11.

44. ------. "Balancing the Books in Space," Physics World [London], 4, No. 10, October 1991, 11-12.

45. ------. "Targets Move but Funds Stay the Same," Physics World [London], 5, No. 5, May 1992, 8.

46. ------. "Degree of Upheaval Needed in Germany," Physics World [London], 5, No. 5, May 1992, 9.

47. ------. "Germany Sets IT Priorities," Physics World [London], 5, No. 6, June 1992, 9.

48. ------. "Just How Well Does Germany Bridge the Gap," Physics World [London], 5, No. 6, June 1992, 11-12.

49. ------. "Lean and Hungry Look for German National Labs," Physics World [London], 5, No. 8, August 1992, 5.

50. ------. "German Government Urged to Reverse Industrial Policy," Physics World [London], 5, No. 9, September 1992, 5-6.

51. ------. "Too Many Hands Grasping the Tiller," Physics World [London], 6, No. 1, January 1993, 11-12.

52. ------. "Riesenhuber Ousted," Physics World [London], 6, No. 2, February 1993, 5.

53. ------. "United but Disenchanted," Physics World [London], 6, No. 2, February 1993, 11-12.

54. ------. "Germany Banks on Market Research," Physics World [London], 6, No. 3, March 1993, 9.

55. ------. "Daimler Wrestles with Recession," Physics World [London], 6, No. 5, May 1993, 9-10.

56. ------. "Revolving Doors in Bonn," Physics World [London], 6, No. 6, June 1993, 7-8.

57. ------. "Germany Sees the Appeal of Foresight," Physics World [London], 6, No. 7, July 1993, 6.

58. ------. "Recession Forces Germany to Tighten Its Belt," Physics World [London], 6, No. 8, August 1993, 9.

59. ------. "German SMEs Shun Collaboration," Physics World [London], 6, No. 8, August 1993, 10-11.

60. ------. "Red Light for 'Blue List' Institutes," Physics World [London], 6, No. 8, October 1993, 9-10.

61. ------. "Germany Looks for a Return to High Standards," Physics World [London], 6, No. 11, November 1993, 8.

62. ------. "Germany Gridlocked," Physics World [London], 6, No. 12, December 1993, 10-11.

63. Smith, Bradford. "Researchers Sans Frontieres," Physics World [London], 6, No. 6, June 1993, 11-12.

64. United States. Congress. Office of Technology Assessment. "Appendix A: R&D Institutions in Germany." In Defense Conversion: Redirecting R&D. Washington: GPO, May 1993, OTA-ITE-552.

65. "United States Retains Share of U.S. Patents," R&D Magazine, June 1993, 21.

66. Venneri, Francesco. "Accelerators Address Nuclear Waste Problems," Physics World [London], 6, No. 8, August 1993, 40-45.

67. Voss, David. "Adapt or Die: Technology Transfer the American Way," Physics World [London], 6, No. 7, July 1993, 30-34.

68. Wagner, H.F. "The Third Energy R&D Programme of West Germany," Energy Policy, 19, May 1991, 392-99.

THE NATIONAL LABORATORY SYSTEM OF FRANCE

Key Judgments

◆ The present French research system, the descendent of a 300-year-old highly centralized government, is itself highly centralized.

◆ R&D facilities are concentrated in the Paris/Île-de-France region; unhappy with this concentration, French authorities have attempted to establish facilities in other areas of the country as well.

◆ Public R&D funding is controlled and funded by two ministries: the Ministry of Higher Education and Research (MESR) and the Ministry of Defense (MoD). Parliament decides on authorizations and appropriations; the process, however is faster and elicits less debate than do similar procedures in the U.S. Congress.

◆ The National Center for Scientific Research (CNRS) is the major French scientific research organ; it grew out of the merger of three scientific research organizations in 1939.

◆ The CNRS, which is subordinate to the MESR, works closely with the universities and the "Grandes écoles."[5] It also sets S&T policy through its series of three-year "Strategic Blueprints" that identify government priorities and specific projects relating to domestic issues, the European Community, and the international community. The latter include joint projects with major powers and projects within the French-speaking community of former colonies and countries influenced by France. **[18**,4]

◆ France, like many other major powers, is being confronted with pressing problems: an aging population, increased unemployment because of technological modernization and immigration from former colonies, the need to maintain the populace's standard of living against these threats, and especially the need to support and enhance France's national self-image and status among the European powers and world-wide. France is determined to be a major force in the emergence of the new Europe. These problems may impact government funding for R&D.

◆ More specifically, the close connection between the CNRS laboratories and teaching institutions may be coming under question. The CNRS's role as a policy-maker and/or policy promoter for its parent MESR may also change as new concerns and challenges

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[5]The "*Grandes écoles*" ("large schools") are a unique French institution, distinct from the universities, for turning out highly trained, top-level managers.

arise as to how and where to allocate government funding in times of growing and competing needs and priorities.

♦ These factors may be further complicated by the 1995 elections. A major shift in the ruling party could result in significant changes in government priorities and a resultant change in R&D policy.

♦ All the above factors make it difficult to draw any comparisons that could be usefully applied to the U.S. situation.

History

The centralized French research system dates back to the reforms of Louis XIV's finance minister, Jean-Baptiste Colbert, who implemented a centralized system of government. [3,194-200]

The principal organ of research in France is the Centre national de la Recherche scientifique (the National Center for Scientific Research) (CNRS). It dates from the October 1939 fusion of three institutions established between the wars: la Caisse nationale de la Recherche scientifique (the National Fund for Scientific Research) (1922), le Service central de la Recherche du ministère de l'Education nationale (the Central Service for Research of the Ministry of National Education) (1936), and le Centre national de la Recherche scientifique appliquée (the National Center for Applied Scientific Research) (1938). In November 1945, the provisional government issued an ordonnance, still in effect, that defined the agency's mission and organization.

The 50-year evolution of the CNRS function and mission can be summarized as follows:

- 1939-1960 — CNRS is composed essentially of laboratories proper
- 1960-1980 — CNRS begins active association with universities, "grandes écoles," and other research organizations
- 1980-1990 — CNRS enters the world of enterprise, and creates interdisciplinary programs and mixed laboratories
- 1990-1992 — CNRS institutes modernization plan and first Strategic Blueprint

Role of Government, Academe, and Industry

The French structure can be seen as a triangle, characterized by an extremely close interrelationship among government, higher education, and industry. The system attempts to maintain a "revolving door" between the universities/"grandes écoles" and science policy-making organs, primarily the CNRS. Indeed, this connection is so close that the Organisation

for Economic Co-operation and Development (OECD) states, "In France, the national center for scientific research (CNRS) is included in the Higher Education sector, whereas in other countries, such as Italy, this type of organization is classified in the Government sector, which obviously affects the breakdown of the R&D effort by sector of performance." [14,76]

Concerning the CNRS's connection with the academic community, the current Strategic Blueprint for 1993-1995 states, "The establishments of higher education (universities, schools) are the first partner of the CNRS." Nearly 1,000 out of 1,360 research units connected with the CNRS are university units. University research and the CNRS have been connected for more than 25 years; these relationships have been reinforced in the last few years. [5,28]

The ties between government and industry are almost as close, with the government at times owning all or most of the major producers. The CNRS has numerous relationships with enterprises: more than 3,500 cooperative contracts, 20 mixed units, and 700 licenses. [5,29] The CNRS has as its mission to promote the advancement of science as well as the nation's economic, social, and cultural progress.

R&D Policy

National Policy Objectives

The CNRS is an independent national institution functioning under the authority of the Ministry of Higher Education and Research (MESR). (See Appendix, p.74) Its mission is to conduct, evaluate, develop, coordinate, and support basic and applied research in the sciences, arts, and humanities aimed at national and international advancement. [15,413] In order to attain this goal, the Center is integrally involved in the functioning of the related institutions.

The current (second) CNRS three-year Blueprint explicitly defines the organization's goals within the context of four major areas of government concern: the economy, the building of Europe, higher education and industry. [5,9]

Regional/International Cooperation

The CNRS prides itself on its broad cooperation with other research agencies throughout France, in Europe, and abroad (particularly North America). France also nurtures research throughout the "francophone" former overseas colonies world-wide, from Africa to

Asia and the Pacific Islands, through Départements d'Outremer (DOM) and Térritoires d'Outremer (TOM). Relationships with these agencies are administered through the Institut Français de Recherche Scientifique pour le Développement Scientifique en Cooperation (ORSTOM) program.

The CNRS has more than 2,000 industrial partners, numerous regional offices throughout France, six foreign offices, 55 conventions with 40 countries, and 4,000 cooperative agreements with foreign laboratories. [8,1] (See Appendix, p.75) Although expressing satisfaction with its nationwide network of closely cooperating sites, the CNRS is pressing for still greater decentralization of activity away from the area surrounding Paris, the Île de France. Since 1989, CNRS has built 130,000 square meters of laboratory space outside the Paris area. Eighty projects are under way to increase scientific research in French regions. [6,2]

Organizational Structure and Funding

The CNRS has a vast network of scientific facilities nationwide, consisting of seven scientific departments and two national institutes. There are four Operational Divisions and seven Inter-disciplinary Research Programs (PIRs). [6,4] Twelve regional offices and seven sub-offices manage the network. [7,2] CNRS has 1,333 research laboratories, 19,698 scientists and professional engineers, and 7,241 technicians and administrative personnel. [7,4] For a list of French public research agencies, government science research policy-makers, and government science research organizations, see Appendix, p.76, 77, 78.

The CNRS 1993 budget was FF11,492 millions (US$2.1 billion). [7,4] The French civilian research budget for 1994 (for public establishments of a scientific and technical nature) shows that of the FF19,069 millions (US$3.467 billion), CNRS will receive FF12,031 millions (US$2.187 billion), with the remaining FF7,038 millions (US$1.28 billion) being allocated to agricultural, transportation and safety, information science, medical, and demographic institutes. Approximately FF5 billion (US$1 billion) is allocated to the French Atomic Energy Commission, Agency for Environment and Energy Oversight, Institute for Exploitation of the Sea, the City for Science and Industry, and the Center for International Cooperation in Agronomic Research. The total budget for the Ministry of Higher Education and Research is FF28,937 millions (US$5.261 billion); other ministries

total FF20,821 millions (US$3.786 billion), bringing the entire civilian budget for research and development to FF49,758 millions (approximately US$10 billion). [2,1202]

<u>Current Issues and Projections</u>

French government policy attempts to satisfy all demands at the same time. Hence government spokesmen not surprisingly provide conflicting views on future trends in French R&D funding emphasis. All express concern about the problems confronting many developed countries: the urban "phenomenon," unemployment, and environmental degradation, noting that the scientific community is obligated to respond to these issues. Government spokesmen also note that basic research cannot be ignored. [4,1] Although acknowledging the importance of addressing society's demands, CNRS has launched a program to develop large-scale instrument projects, for example, accelerators and reactors. At the same time, the agency is emphasizing its major role in building Europe. The CNRS has three primary strengths that allow it to play a leading-edge role in European science:

- multidisciplinary skills, embodied in its seven scientific departments;
- efficient management well adapted to modern research, combining rigor and operational flexibility;
- open-minded cooperation, through numerous partnerships with higher education, other research agencies, and industry. [7,1]

The four goals of the CNRS reflect the thinking of government leaders. These goals emphasize an enlargement rather than a shrinking of the government's role in R&D policy and investment:

1) The economy: Unemployment and the problems associated with assimilating a large non-French population are two major domestic problems. Data indicate, however, that government funding of research has remained even.

2) The building of Europe: France intends to remain an active participant in scientific research in Europe; hence the funding from CNRS will need to remain constant in order for France to compete in this area.

3) Higher education: the rapprochement between government research funding and the universities is proposed to become even closer in coming years. Such a link will demand

increased funding. There is some disagreement concerning this policy, however. Édouard Brézin, Chairman of CNRS, has stated, "Concerning the relationship between the career of researcher and that of academic . . . I am not among those who believes that every researcher should teach." [6,1]

4) Industry: Improvement in France's standard of living depends on technological development. The awareness of technology's resultant environmental degradation will drive a large segment of the R&D budget.

Institutional Culture

An important factor, tracing its origins to Colbert, is the French view of science as a means of enhancing national power and prestige. Thus, France views itself as a major force in building Europe and, on a somewhat lower key, attempts to maintain its Third-World influence by means of its DOM and TOM joint programs and its network of research (often medical) laboratories throughout the French-speaking world. There emerges, therefore, a conflict between national-interest goals and the need to deal with pressing social issues at home.

In April 1993, François Fillon, Minister of Higher Education and Research, spoke of budgetary constraints at the CNRS Colloquium at Strasbourg. He noted that no sector was being spared. [9,14] At the same time, France's historical tradition was acknowledged by Jean-Louis Lacombe, Technical Director of Matra-Marconi Space (Paris), who noted that "the French system is the historic result of a scientific Colbertism [self-sufficiency], limited by available national financial resources. It can either seek to perpetuate itself by inspiring the policy of the community or consent to an evolution toward more liberal practices." [9,78]

Since the end of World War II, France has had a centralized economic system dominated by state-owned companies and national economic decision making by government institutions. Despite strong support for science from the government, France cannot afford all the major projects currently being developed by its scientists. That conclusion, reached in a recent report issued by the Conseil des Grands Equipements Scientifiques (CGES), led Minister Fillon to call for an immediate debate on the country's science priorities. [16,5]

There generally seems to be little disagreement about government funding for R&D projects. However, Minister Fillon asked thousands of French researchers to respond to

issues raised in a 75-page report prepared by a panel of science experts and published in January 1994. Over 60,000 copies of the report have been distributed and six national debates have been held in an attempt to find a consensus concerning the country's long-term research policy. Conclusions are to be submitted to Parliament later this year. [17,8] A central question posed in the report is "What should our researchers be doing, and why?" Results of a national poll published in April 1993 indicate that 62 percent of all French people are pessimistic about life for their children in 2010, suggesting that a potential conflict regarding the allocation of government resources could be looming.

Comparison with the U.S. Laboratory System

A distinctive characteristic of the French system is the close connection between CNRS laboratories and French teaching institutions. Although some questions have been raised about the wisdom of this connection (witness Brézin's comment concerning researchers who teach), no moves have been under taken to change the relationship. As a subsidiary agency of the Ministry of Higher Education and Research, the CNRS still passes on the policies of its parent organization at the ministerial level. No comparable connection exists in the United States.

France has inherited a centuries-old system of highly centralized government and social patterns. Thus, Paris and, by extension, its surrounding area remain today the focus of high-level activity in all fields. The French government has long been aware of this fact and has been aggressively striving to decentralize the quantity and quality of higher institutions throughout the nation. CNRS President Kourilsky has said, "Our efforts to develop laboratories in France's regions are based on scientific priorities. We have created new research poles, centers for excellence in scientific research throughout the major cities of France." [6,2] Since 1989, 80 projects to increase scientific research have been established in French regions. [6,2] Although promoting the propagation of research throughout France, CNRS nevertheless retains control and management of the research, emphasizing its centralizing focus.

No meaningful comparison can be made between the French national research system and the U.S. research system because virtually all French research is conducted under the auspices of the government, either through research grants to universities and laboratories or

through direct ownership of corporations. There is no evidence at this time to suggest that the French government will divest itself of its leading role in funding and directing national research and development. While other nations are actively diverting government funds to domestic needs, privatizing their national laboratories or re-directing their focus, France seems to be unable to decide which direction to take: divest itself of its governmental role and allow industry to assume responsibility for R&D while addressing social questions, or follow the centuries-old tradition of government sponsorship of science and research.

There is some question as to whether CNRS itself is under threat. Are hidden changes being implemented within the organization? France's research minister has initiated a national consultation on research priorities, and the leading civilian organization for R&D funding is questioning R&D direction. [10,3] The very act of raising the issue in public may indicate that a dialogue is about to take shape.

Facing the difficulties plaguing all developed countries (economic recession, increased global competition, a rapidly aging population, and an increasingly expensive welfare system), France is uncertain how to proceed in its policy of research funding. Culturally unable to divest itself of its leadership role, the government must find some way of financing its increasingly expensive social welfare system in order to maintain public peace and order. Students, Air France workers, auto workers, and farmers have all staged public demonstrations and riots in 1994. The "wild card" in this dilemma is the change in the political climate resulting from the probable defeat of the Socialists and victory by the Gaullists in next year's national elections. If a conservative government comes to power, it might have the public support and resultant political will to make fundamental changes in how government operates. Until that time, however, France's research picture will remain fundamentally the same as it is today.

SOURCES

1. "As French Get Older, Social Security Gets Wobbly," New York Times, August 28, 1992, A4.

2. Budget: "Recovery of Balance Without Scientific Priority," la Recherche [Paris], 24, No. 259, November 1993, 1202.

3. Chesnais, François. "The French National System of Innovation." Pages 192-229 in Richard R. Nelson, (ed.) National Innovation Systems: A Comparative Analysis. New York: Oxford University Press, 1993.

4. Centre National de la Recherche Scientifique (CNRS) [Paris], "La Note." Note d'Information du CNRS, No. 4, November 1993.

5. ------. Schéma Stratégique du CNRS: 1993-1995 [Paris], September 1993.

6. ------. 1992 Annual Report. Paris: n.d., ca. 1993.

7. ------. 1992 Annual Report. Paris: n.d., ca. 1993. (4-page insert.)

8. ------. Scientific Trends and Program Planning. Interdisciplinary Research Environment Program. Paris: December 1990.

9. ------. European Perspectives on Scientific Research (Perspectives Européennes de la Recherche Scientifique). Actes du Colloque. 22 et 23 avril 1993, Session Plenière du Comité national de la Recherche scientifique. Strasbourg, Palais des Congrés.

10. "CNRS under Threat?" Physics World [London], 7, No. 3, March 1994, 3.

11. Devaquet, Alain. L'Amibe et l'Étudiant. Université et Recherche: l'État d'Urgence (The Amoeba and the Student. The University and Research: The State of Emergency). Paris: Éditions Odile Jacob, 1988.

12. "Ending an Epoque of Entitlement," Washington Post, March 24, 1994, D11.

13. Kellerman, E. Walter. Science and Technology in France and Belgium [London], Longman, 1988.

14. Organisation for Economic Co-operation and Development (OECD). Main Science and Technology Indicators [Paris], No. 2, 1992.

15. Piccirelli, Annette (ed.). International Research Centers Directory, 1992-93. (6th ed.). Detroit: Gale Research, 1991.

16. Smith, Bradford. "France Gets Ready for Tough Decisions on Large Facilities," Physics World

[London], 6, No. 10, October 1993, 5.

17. ------. "France Launches Nationwide Consultation," Physics World [London], 7, No. 3, March 1994.

18. Wolff, Claude. "Understanding French Government R&D Investment Decisions." (Paper presented at U.S. D.o.E./Sandia Laboratory, June 1994, Albuquerque, New Mexico.)

CONCLUSIONS

Post-Cold War European R&D is in the process of self-analysis and restructuring. The United Kingdom, France, and Germany, have different approaches to change that are based upon their traditions, cultures, and immediate economic situations.

The U.K. is attempting to salvage its research system through large-scale privatization of government-owned or government-sponsored laboratories. The process of weaning laboratories away from their primary government support has shrunk the research system, causing the abandonment of some promising projects and reductions in research personnel. This conversion from government R&D to more market-oriented R&D is still in flux. A recent government White Paper expressed commitment to the privatization of applied science facilities, but did not address the issue of conversion in defense laboratories. The restructured laboratories will have a management style that is closer to that of U.S. national laboratories, but with a declining role for government funding as they move into a more competitive work-for-others environment. The White Paper recommendations have been described as an attempt to catch up with the U.S. and its blend of science, technology, industry, and academe. While U.K. defense laboratories will continue to be independently supported for security reasons, there is likely to be much more collaborative research among the privatized laboratories and other partners in the European Union.

Most German R&D (about 60 percent) is supported by industry and has a strong technological and business infrastructure. Germany prides itself on its efficiency. In 1988 Germany exported four times as much as the U.S. per capita. The role of the federal government in R&D is still very important, however. Together with the German states, it supports basic research in the Max Planck institutes and big science projects through the National Research Centers (GFEs).

The total research budget of Germany has doubled in the last decade to about DM80.7 billion (US$53.8 billion). The government's major R&D funding provider and policy maker is the BMFT, which has a budget of about DM9.6 billion (US$6.4 billion). The BMFT is undergoing change because of the current recession, increasing global economic competition, and the recent reunification with the former East Germany. As a

result, the BMFT has been committed to funding research in the former East Germany at the expense of institutions in the former West Germany. The result is declining budgets for some of the National Research Centers that correspond fairly closely to the DOE laboratories in the U.S. The reductions in funding have affected the nuclear-based facilities the most, probably because of social and political pressures.

The German Research System differs from the U.S. in that there is no counterpart in the U.S. to the BMFT or the Fraunhofer Society Institutes. The U.K. has looked at the German system as a model for some of its privatization efforts and had planned to set up "Faraday Centres," along the lines of the Fraunhofer Society. Ultimately, this plan was rejected in favor of the expansion of existing projects and institutions. It is now evident that the Fraunhofer Society Institutes, which enjoy a reputation for being almost self-funding, business-like, institutions, are ultimately 80 percent funded by the BMFT, through indirect contracting.

In France, the research system is highly centralized and likely to remain so. The CNRS is the primary R&D organization, with a 1994 budget of $2.187 billion. The CNRS has indicated that it places a very high priority on the French universities and schools: it has ties with 1,000 of the 1,360 research facilities in universities. France, like the U.K., is undergoing difficult economic times because of rising unemployment and increasing global economic competition. Except for some efforts at decentralizing itself away from its hub in Paris, the CNRS seems to be undergoing little change despite these social and economic pressures. Indeed, it seems that the role of the government in French R&D is likely to increase. Thus, the French research system and the U.S. and U.K systems are headed in opposite directions. There is little indication that the French government will make any drastic changes in the near future, although a national debate is taking shape.

For a comparison of the relative investments in R&D by the U.K, France, Germany, and the U.S. see Appendix, pp.79, 80, 81.

The U.S. is still a model for the rest of the world in its successful blending of government, industry, and university R&D. What the European research systems reflect is a renewed emphasis on the importance of university and applied research and a clear sense of urgency about their role in increasing global economic competitiveness. Ultimately, for both

the U.S. and Europe, capitalizing on innovations as quickly as possible are the keys to a higher standard of living and national prestige.

The major national research systems of Europe are individually and collectively trying to establish a balance between short-term applied research and long-term basic research.

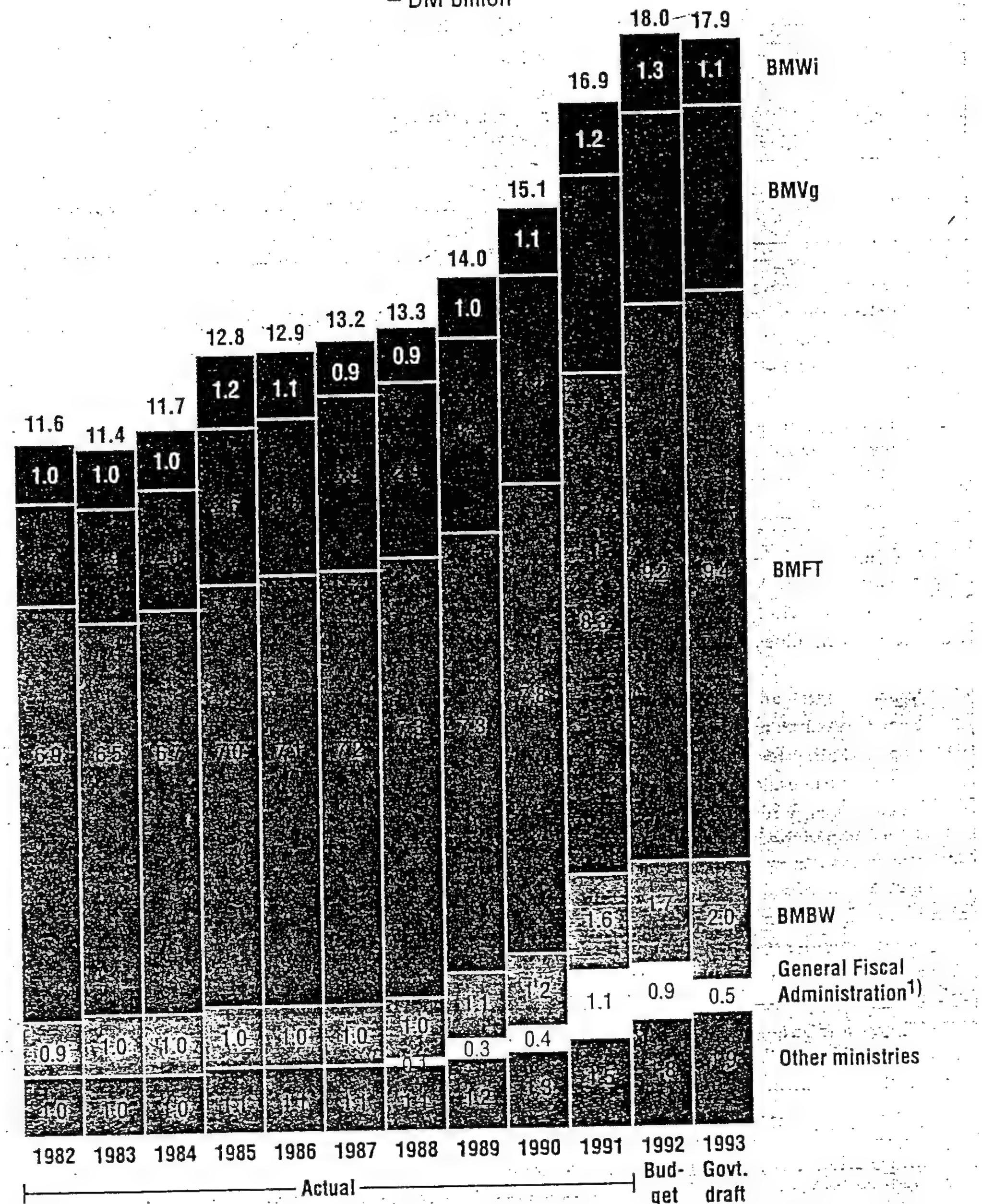
Currently, when funds are tight, long-term research is undergoing increased criticism and support is moving toward short-term, cost-saving policies that emphasize the benefits of near-term research that can be expected to produce revenue-generating goods and services.

Assuming a correlation between funding and economic cycles, as the European economies recover, the criticisms will likely give way to higher expectations of research and a return to increased funding of high profile and prestigious research projects.

APPENDIX

Shares of ministries in the Federal Government's R&D expenditure, 1982 to 1993

– DM billion –



1) Including financial assistance pursuant to Art. 104a para 4 of the Grundgesetz to Länder with a weak structure in order to invest in the promotion of research and technology (1989 to 1992) and including from 1991 onwards – as a result of German unity – resources for higher education institutions and research as well as for industry-related research institutions.

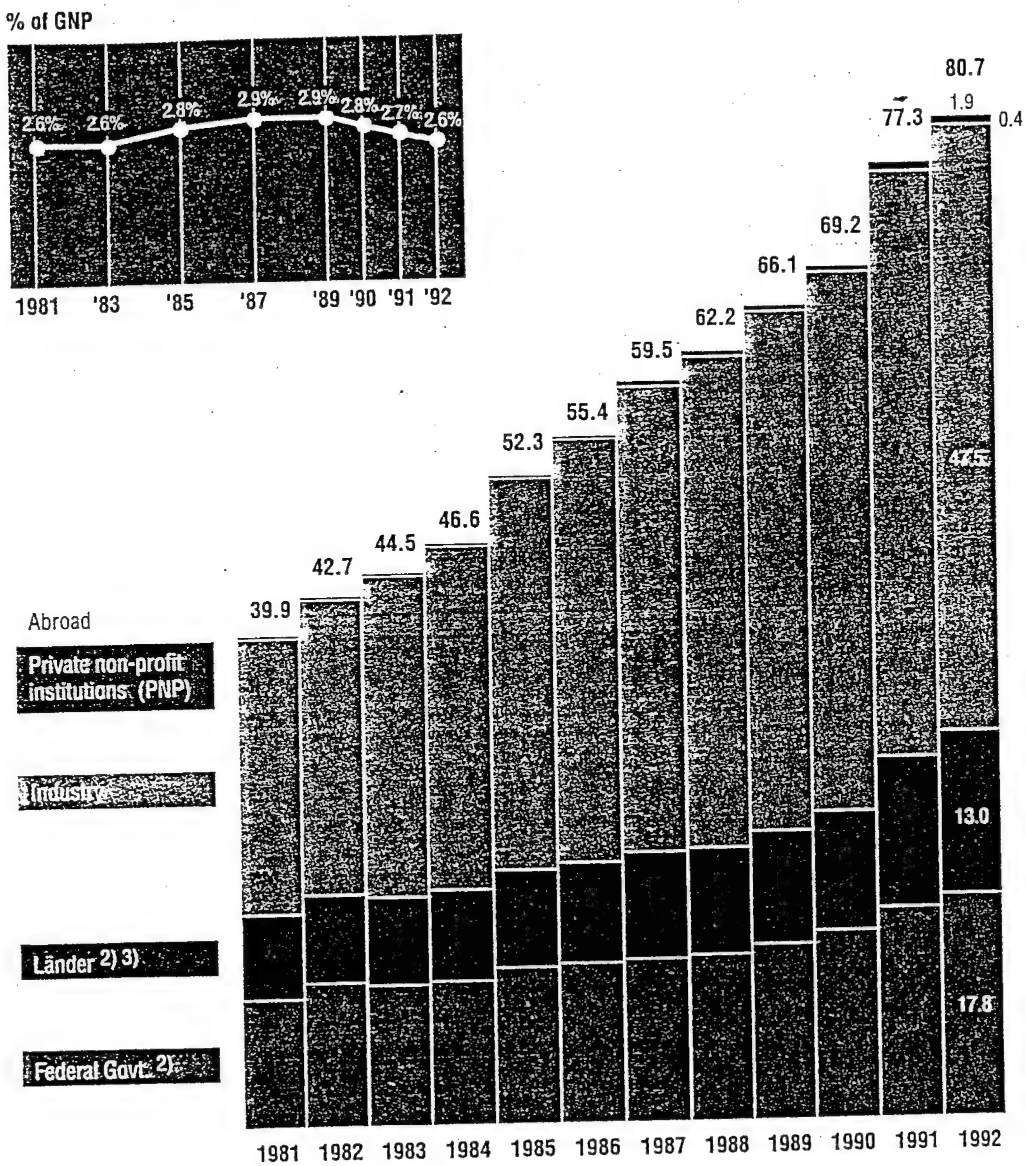
BMFT, BuFo '93

Source: BMFT

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 69.

Total research budget

R&D expenditure of the Federal Republic of Germany* by financing sectors[1)]
– DM billion –



* Up to and including 1990 former West Germany, from 1991 onwards Germany as a whole.

1) Estimated in some cases, actual figures for Federal Government up to and including 1991, Länder up to and including 1990, industry up to and including 1989.

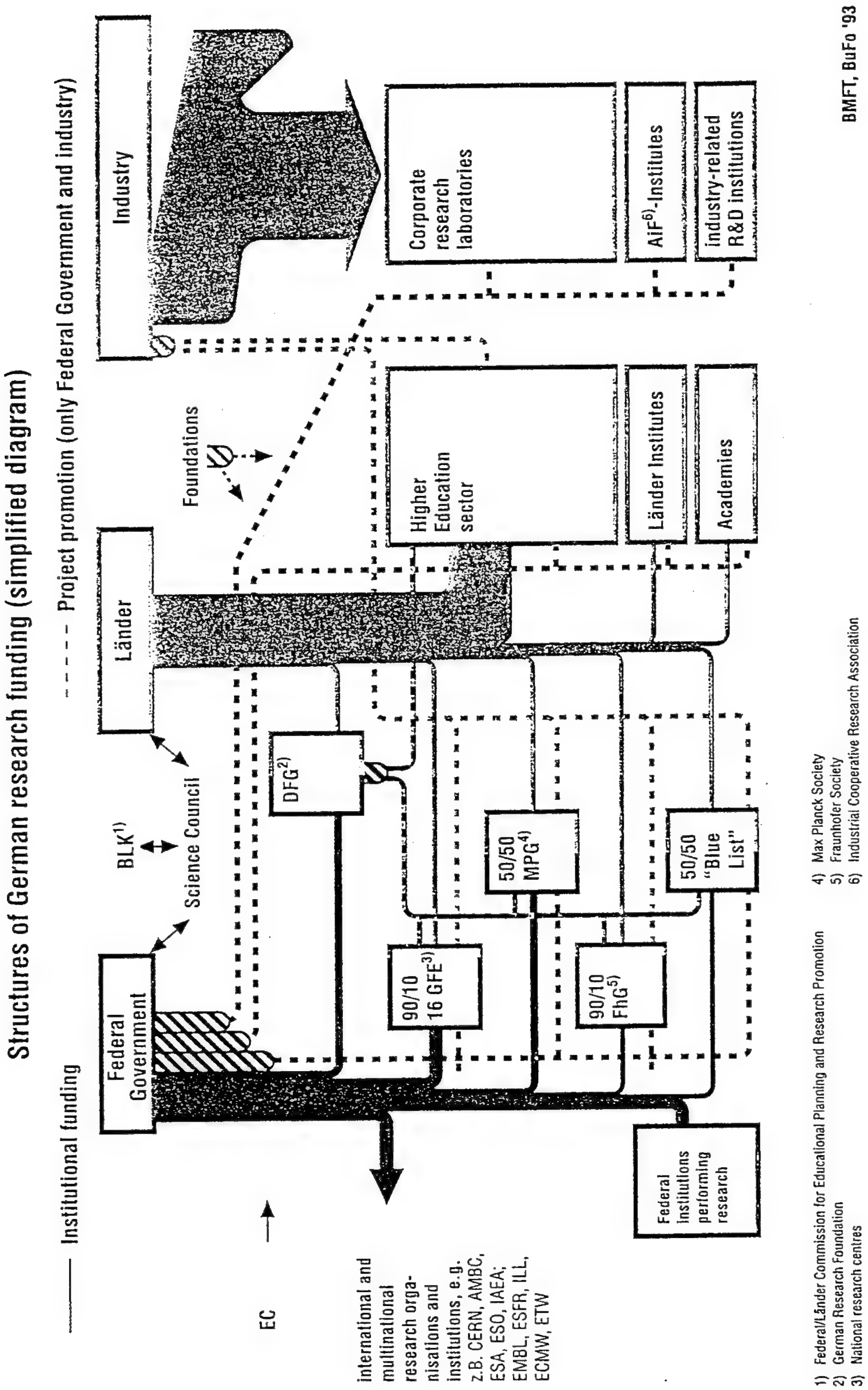
2) Federal institutions only included with their R&D shares, Länder institutions only included with their R&D shares from 1985 onwards.

Source: BMFT

3) A new computing procedure for research and development (affecting Länder R&D expenditure) was introduced in the higher education sector by the 1987 survey; the data of earlier years were revised here accordingly so that Länder R&D expenditure deviates from the data in previous publications.

BMFT, BuFo '93

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 59.



Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 18.

German National Research Centers

1 Alfred-Wegner Institute for Polar & Marine Research
(AWI)
27568 Bremerhaven
Columbusstrasse
Telephone: 0471-4831-0

2 German Electron-Synchrotron
(DESY)
22607 Hamburg
Notkestrasse 85
Telephone: 040-8998-0

3 Cancer Research Center of Germany
(DFKZ)
69120 Heidelberg
Im Neuenheimer Feld 280
Telephone: 06221-42-0

4 German Aerospace Research Establishment
(DLR)
51147 Cologne
Linder Hoehe
Telephone: 02203-601-0

5 Institute for Biotechnology Research
(GBF)
38124 Braunschweig
Mascheroder Weg 1
Telephone: 0531-6181-0

6 Potsdam Earth Science Center
(GFZ)
14473 Potsdam
Telegrafenberg
Telephone: 0331-310-0

7 GKSS Research Center--Geesthacht
(GKSS)
21502 Geesthacht
Max Planck Strasse
Telephone: 04152-87-0

8 Society for Mathematics and Data Processing
(GMD)
53731 St. Augustin (near Bonn)
PO Box 13 16
Schloss Birlinghoven
Telephone: 02241-14-0

9 GSF Research Center
(GSF)
85764 Oberschleissheim
Ingolstaedter Landstrasse 1
Telephone: 089-3187-0

10 Center for Heavy-Ion Research
(GSI)
64220 Darmstadt
PO Box 11 05 52
Planckstrasse 1
Telephone: 06151-359-1

11 Hahn Meitner Institute
(HMI)
14109 Berlin
Glienicker Strasse 100
Telephone: 030-8009-1

12 Max Planck Institute for Plasma Physics
(IPP)
85748 Garching (near Munich)
Boltzmannstrasse 2
Telephone: 089-3299-01

13 Juelich Research Center
(KFA)
52425 Juelich
PO Box 19 13
Telephone: 02461-61-0

14 Karlsruhe Nuclear Energy Center
(KfK)

76021 Karlsruhe
PO Box 36 40
Telephone: 07247-82-0

15 Max Delbrueck Center for Molecular Medicine
(MDC)
13125 Berlin-Buch
Robert Roessle Strasse 10
Telephone: 030-9463278

16 Leipzig/Halle Environmental Research Center
(UFZ)
04318 Leipzig
Permoserstrasse 15
Telephone: 0341-2352242

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 140-41.

Joint research promotion by Federal and Länder governments, 1990 to 1992 *)
(Institutional funding [1])
– DM million –

Institutions	1990 Actual			1991 Actual			1992 Budget		
	Total	Federal Government	Länder	Total	Federal Government	Länder	Total	Federal Government	Länder
Max Planck Society	958.2	471.0	487.2	1,003.4	501.7	501.7	1,157.0	575.9	581.2
German Research Foundation	1,143.3	669.3	474.1	1,262.8	733.7	529.1	1,500.8	865.5	635.3
of which: – General promotion	737.7	368.8	368.8	821.9	412.1	409.7	912.5	456.3	456.3
– Collaborative research centers (SFB)	359.1	269.3	89.8	379.8	285.0	94.8	413.9	310.4	103.5
– Heisenberg Programme ...	11.9	6.0	6.0	12.4	6.2	6.2	11.4	5.7	5.7
– Peace and conflict research	2.9	2.3	0.6	3.6	2.9	0.7	3.6	2.9	0.7
– High-tech research	26.0	19.5	6.5	18.8	11.3	7.5	18.8	11.3	7.5
– Promotion of the socio-economic panel	2.6	1.3	1.3	3.3	1.7	1.6	3.5	1.8	1.8
– Promotion of postgraduate studies [2])	3.1	2.0	1.1	20.6	13.3	7.2	55.0	36.1	18.8
– Promotion of professorial candidates [2])	0.0	0.0	0.0	2.5	1.3	1.2	82.2	41.1	41.1
Peace and Conflict Research Centre, Bonn	0.5	0.4	0.1	0.5	0.4	0.1	0.6	0.4	0.1
Fraunhofer Society [3])	297.7	244.0	53.7	304.1	248.8	55.3	494.1	403.6	90.5
Programme of Academies of Sciences	37.5	18.8	18.8	40.1	20.1	20.1	59.4	29.7	29.7
National Research Centres ..	2,655.1	2,372.7	282.5	2,695.4	2,399.6	295.8	2,903.8	2,594.2	309.6
of which: – Alfred Wegener Institute for Polar and Marine Research, Bremerhaven (AWI)	82.1	72.9	9.2	98.2	88.3	9.9	105.3	94.6	10.6
– German Electron Synchrotron, Hamburg (DESY)	269.6	246.8	22.8	258.5	232.4	26.1	258.9	233.0	25.9
– German Aerospace Research Establishment, Cologne (DLR)[4])	394.3	340.0	54.3	390.7	327.0	53.7	410.1	356.8	53.3
– German Cancer Research Centre, Heidelberg (DKFZ)	140.0	126.0	14.0	152.6	137.3	15.3	144.6	130.1	14.5
– Biotechnological Research Company Ltd., Braunschweig Stöckheim (GBF)	54.0	48.6	5.4	56.9	51.2	5.7	62.7	56.4	6.3
– Geoscientific Research Centre, Potsdam (GFZ).....	0.0	0.0	0.0	0.0	0.0	0.0	49.3	44.3	4.9
– GKSS-Geesthacht Research Centre, Ltd., Geesthacht (GKSS)	95.8	86.2	9.6	97.8	88.0	9.8	121.9	109.7	12.2
– Mathematics and Data Processing Company Ltd., St. Augustin near Bonn (GMD)	120.9	108.8	12.0	120.6	108.5	12.1	127.1	114.4	12.7

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 86.

Institutions	1990 Actual			1991 Actual			1992 Budget		
	Total	Federal Government	Länder	Total	Federal Government	Länder	Total	Federal Government	Länder
– GSF - Environmental and Health Research Centre Ltd., Neuherberg near Munich (GSF)	144.5	131.7	12.8	148.3	135.2	13.1	150.1	136.8	13.3
– Heavy Ion Research Centre Ltd., Darmstadt (GSI)	136.1	125.0	11.1	125.9	114.5	11.4	121.8	109.6	12.2
– Hahn-Meitner Institute Berlin Ltd., Berlin (HMI)	110.4	99.4	11.0	103.1	92.8	10.3	114.1	102.6	11.4
– Max Planck Institute for, Plasmaphysics, Garching near Munich (IPP)	95.4	85.9	9.5	93.5	84.2	9.4	97.8	88.0	9.8
– Jülich Research Centre Ltd., Jülich (KFA)	499.8	440.3	59.5	516.9	455.5	61.4	509.5	448.4	61.1
– Karlsruhe Nuclear Research Centre Ltd., Karlsruhe (KfK)	512.4	461.1	51.3	532.3	474.7	57.6	522.8	472.1	50.7
– Max Delbrück Centre for Molecular Medicine, Berlin-Buch (MDC)	0.0	0.0	0.0	0.0	0.0	0.0	63.4	57.1	6.3
– Environmental Research Centre Ltd., Leipzig-Halle (UFZ)	0.0	0.0	0.0	0.0	0.0	0.0	44.5	40.1	4.5
Blue List Institutions [5])	480.7	252.9	227.8	504.3	264.6	239.6	1,043.4	534.4	509.0
Deutsche Akademie Leopoldina, Halle/Saale	0.0	0.0	0.0	1.4	1.4	0.0	2.0	1.6	0.4
Total	5,573.1	4,029.0	1,544.1	5,812.0	4,170.4	1,641.6	7,161.1	5,005.2	2,155.9

*) Up to and including 1991 former West Germany, as from 1992 Germany as a whole.
[1]) The above sums also include funds provided on the basis of special agreements between Federal and Länder governments; this leads to deviations from the financing formulae laid down in the framework agreement on research promotion pursuant to Art. 91b of the Grundgesetz.
[2]) Including special funds from the Special University Programme II and the University Renewal Programme.
[3]) Not including institutional funding by the Federal Ministry of Defence as the institution is not subject to joint funding by Federal and Länder governments.
[4]) Not including a DM 24 million lump-sum payment by the Federal Ministry of Defence as the institution is not subject to joint funding by Federal and Länder governments.
[5]) All data budgeted.

Source: Economic plans as printed in Federal Budgets 1991 to 1993, Federal/Länder Commission for Educational Planning and Research Promotion, and BMFT calculations.

Rounding error

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 87.

Federal R&D expenditure by promotion areas and promotion priorities
– DM million –

	Promotion area / Promotion priority	1990 Actual	1991 Actual	1992 Budget	1993 Govt.draft
A	Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities	1,695.4	2,556.9	2,681.5	2,958.2
A1	Basic funding MPG	471.0	499.3	555.0	622.8
A2	Basic funding DFG	638.1	697.1	766.7	834.9
A3	Basic funding FhG	166.0	182.0	333.3	364.3
A4	Basic funding of institutions and restructuring of research in the new Länder – transitional funding of Academies of Sciences –	—	450.0	12.0	—
A5	Expansion and construction of universities[1)]	420.3	728.5	1,014.6	1,136.2
B	Large-scale equipment for basic research	962.9	973.3	999.5	1,051.2
C	Marine research and marine technology; polar research	230.3	241.7	276.1	261.7
C1	Marine research	115.8	103.5	129.4	130.2
C2	Marine technology	58.1	68.5	73.5	60.9
C3	Polar research	56.4	69.6	73.2	70.6
D	Space research and space technology	1,388.1	1,544.7	1,797.0	1,815.9
E	Energy research and energy technology	1,262.4	1,215.1	1,188.7	1,127.2
E1	Coal and other fossil fuels	153.0	114.9	122.2	108.5
E2	Renewable energies and energy conservation	289.4	322.6	391.0	348.1
E3	Nuclear energy research (excluding decommissioning of nuclear facilities)	627.4	573.3	470.1	454.9
E4	Decommissioning of nuclear facilities; risk sharing[2)]	—	—	—	9.7
E5	Nuclear fusion research	192.5	204.3	205.4	206.1
F	Environmental research; climate research	711.8	895.9	1,049.2	1,071.1
F1	Ecological research	354.2	407.7	493.2	515.3
F2	Environmental technologies	271.2	360.1	396.3	383.1
F7	Climate and atmospheric research	86.4	128.0	159.8	172.7
G	Research and development in the service of health	589.2	638.9	703.7	744.1
H	Research and development to improve working conditions	130.5	140.0	136.9	132.8
I	Information technology (including production engineering)	735.7	855.1	1,030.6	1,045.2
I1	Computer science	207.4	232.5	209.7	215.3
I2	Basic information technologies	355.9	395.8	542.7	553.4
I3	Application of microsystems (including microelectronics and microperipherals)	64.8	98.4	140.3	140.6

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 70.

Scientists Employed in East Germany

1989		1992	
University	14,000		14,000
Non-university[1]	40,000		7,100
Industry	86,000		15,000
		Government research institutes	1,000
		University integration scheme	2,000
		Temporary employment scheme	2,500
Humanities and social sciences	8,000		
Total	148,000		41,600

[1] Before 1989, chiefly Academy of Sciences (24,000). After 1992, includes 3 national laboratories, twenty-four joint/federal state institutions, twenty-one Fraunhofer facilities, 2 Max Planck institutes, and twenty-nine Max Planck groups.

Source: Richard Sitman, "United But Disenchanted" Physics World, 6, No. 2, February 1993, 12.

Federal Government schemes to promote industrial R&D in the new Länder

Objective	Scheme	1992 Budget DM million
To create and increase technological competitiveness	Project promotion under specialised BMFT programmes	151.4
	Special funds "Aufschwung Ost", BMWi/BMFT	195.1
	Cooperative industrial research	68.1
To promote new technology-based firms	New technology-based firms, BMFT (NTBFs)	43.2
	Establishment and expansion of technology parks and research incubators, BMFT	9.7
To build up and strengthen SMEs	R&D personnel costs subsidy in the East, BMWi	47.9
	Research-personnel increase promotion in the East, BMFT	19.3
	Contract research and development, BMFT (East-West/East)	33.5
	Innovation promotion scheme, BMWi	8.4
To develop an R&D-supporting infrastructure	Agencies for Technology transfer and Innovation Promotion, BMWi	16.5
	Innovation consultants at Chambers of Industry and Commerce, BMFT	0.4
	Centres for Information and Consultancy, BMFT	7.4
	Industry-related specialised information, BMWi	6.5
Total		**607.4**

Source: BMFT

BMFT, BuFo '93

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 104.

Schemes of the Federal Government to promote research and development in trade and industry in the new Länder
– DM million–

Ministry/Scheme	1991	1992	1993[1])
Federal Ministry for Research and Technology			
1 Project promotion under specialised programmes	121.6	133.4	180.0[3])
2 Promotion of projects at industry-related R&D institutions [2])	–	92.4	–
3 New technology-based firms	13.6	43.2	64.5
4 Establishment and expansion of technology parks	6.3	9.7	7.0
5 Contract research and development	13.0	33.5	56.0
6 Research-personnel increase promotion	10.6	19.3	29.5
7 Production engineering (indirect specific CIM promotion)	–	18.0	35.0
8 Innovation and consultancy centres	14.8	7.4	5.0
9 Pilot scheme on innovation consultants at Chambers of Industry and Commerce	0.4	0.4	0.5
Federal Ministry for Research and Technology – subtotal	180.3	357.3	377.5
Federal Ministry of Economics			
1 Industrial cooperative research	67.2	68.1	45.0
2 R&D-personnel costs subsidy in East Germany	–	47.9	107.0
3 Innovation promotion	0.2	8.4	30.0
4 Technology transfer	4.8	16.5	26.0
5 Industry-related specialised information	3.7	6.5	4.0
6 Design promotion	–	–	4.0
7 Promotion of projects at industry-related research institutions [2])	59.3	102.7	100.0
Federal Ministry of Economics – subtotal	135.2	250.1	316.0
Total	315.5	607.4	693.5

[1]) Budgeted; including special funds for "Development assistance for the new Länder" (rounded off).
[2]) Appropriations under departmental budget 60.
[3]) Estimated total of a large number of individual budgetary items.

Source: BMFT

Rounding error

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 105.

The 25 Largest Manufacturing Companies in Germany (Year 1989)

Company	Main Activity	Founded (Year)	Sales (Billion DM)[a]	Employees (Thousand)	R&D Expenditure (Million DM)
Daimler-Benz[b]	Vehicles/electrical/aerospace	1882	76.4	368.2	5494
Volkswagen	Vehicles	1938	65.4	250.6	2300
Siemens[c]	Electrical/electronics	1847	61.1	365.0	6875
VEBA	Energy/chemicals	1929	49.2	94.5	370
BASF	Chemicals	1865	47.6	137.0	1954
Hoechst	Chemicals	1863	45.9	169.3	2621
Bayer	Chemicals	1863	43.3	170.2	2695
RWE	Energy	1898	38.9	78.2	n.a.
Thyssen	Steel/machinery	1867	34.2	133.8	735
Bosch	Electrical	1886	30.6	174.7	1803
BMW	Vehicles	1916	26.5	66.3	ca. 3300
Ruhrkohle	Coal mining	1968	23.4	124.8	273
Mannesmann	Machinery	1890	22.3	125.8	518
Opel	Vehicles	1862	20.8	54.6	706
Metallgesellschaft	Metals/plant engineering	1881	20.1	24.5	n.a.
Ford	Vehicles	1925	19.8	48.2	n.a.
Krupp	Steel/machinery	1811	17.7	63.6	275
MAN	Machinery	1840	17.1	63.7	415
Deutsche Shell	Petroleum	1902	16.9	3.3	47
Preussag[d]	Energy/oil	1923	16.4	65.7	200
Hoesch	Steel	1871	15.9	52.0	n.a.
Degussa	Chemicals/metals	1873	14.4	33.7	422
Bertelsmann	Publishing	1835	12.5	43.7	—
IBM Deutschland	Electronics	1910	12.4	31.1	n.a.
Henkel	Chemicals	1876	11.6	38.1	359

[a]One billion = 1000 million.
[b]Not including Messerschmitt-Bölkow-Blohm (MBB), which was acquired by Daimler-Benz in 1989.
[c]Not including Nixdorf, which was acquired by Siemens in 1990.
[d]Including Salzgitter, which was acquired by Preussag in 1989.
Sources: Die Zeit, 17 August 1990, p. 24; *Handbuch der deutschen Aktiengesellschaften 1989/90*. Darmstadt: Hoppenstaedt, 1990/91; data on R&D from the firms' annual reports and personal correspondence.

Source: Keck, Otto. "The National System for Technical Innovation in Germany." Page 137 in Richard R. Nelson (ed.). National Innovation Systems: A Comparative Analysis. Oxford: Oxford University Press, 1993.

Actual expenditure on energy research 1984–89 (DM million).

Activity forming part of the Federal Ministry for Research and Technology statement for present and future R&D activities	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Coal and other fossil energy sources						
Prospecting for extraction and treatment of coal	31.5	40.9	42.7	49.3	37.7	28.5
Prospecting for extraction and treatment of other fossil energy sources	36.5	12.6	28.0	22.9	22.2	21.8
Fuel and power station technology for coal utilization	60.7	67.4	59.9	63.8	73.9	61.6
Coal liquefaction	81.0	61.5	67.2	58.4	25.2	14.6
Coal gasification	71.7	46.5	28.4	22.9	20.3	15.6
Other and generic activities with fossil energy sources	14.7	13.9	14.2	10.3	11.6	5.1
Subtotal without national research centres	296.2	242.8	240.4	227.6	190.9	147.2
National research centres	16.3	8.8	10.8	9.4	9.9	9.4
Subtotal of the promotion priority	312.5	251.6	251.2	237.0	200.8	156.6
Renewable energy sources and conservation						
Photovoltaics	59.1	53.3	57.8	60.1	70.9	82.5
Wind energy	8.9	10.2	12.1	17.8	16.0	12.4
Application systems for Southern climatic conditions	52.9	43.8	31.4	31.3	35.9	32.5
Other renewable energies	14.9	13.3	2.8	4.9	3.3	12.1
Electricity and district heating	18.4	12.8	10.4	8.7	11.6	9.7
Energy-saving industrial process	24.2	30.5	18.2	12.9	14.0	12.8
Energy stores	8.5	13.9	12.6	13.8	5.5	10.2
Hydrogen	8.2	6.1	5.4	8.3	10.0	15.7
Energy conservation and solar energy utilization (households, small-scale consumption)	22.4	13.8	12.8	16.2	19.2	21.1
Subtotal without national research centres	217.5	197.7	163.5	174.0	186.4	209.0
National research centres	21.3	23.5	25.8	22.4	24.5	25.9
Subtotal of the promotion priority	238.8	221.2	189.3	196.4	210.9	234.9
Nuclear energy research						
Breeder reactors (SNR 300 including relevant R&D)	412.9	441.2	310.9	30.3	66.2	54.1
Breeder reactors (further development)	30.2	33.3	23.1	28.5	31.9	31.2
Breeder reactors (fuel cycle)	6.9	5.9	4.8	4.1	3.1	2.2
High temperature reactors (THTR 300)	282.6	242.2	2.6	2.2	1.2	0.1
High temperature reactors (further developments)	18.9	19.3	27.6	34.3	30.1	23.4
Other reactor development	6.8	5.7	0.7	0.2	1.0	0.4
Nuclear fuel supply (without uranium enrichment)	7.8	6.6	24.5	6.2	2.1	1.2
Uranium enrichment	29.0	19.3	7.8	9.8	9.2	0.4
Reprocessing and recycling of nuclear fuel Monitoring of fissible material	50.7	41.4	34.7	37.1	37.6	26.7
Treatment and conditioning of radioactive waste	35.2	32.4	9.1	9.9	8.3	4.8
Ultimate storage of radioactive waste	100.1	146.6	127.0	112.7	38.7	31.0
Dismantling of nuclear facilities	6.7	3.9	5.2	15.4	14.2	23.6
Other and generic activities for waste disposal	3.0	1.8	1.4	1.4	0.8	1.1
Reactor safety research (light water reactors)	84.4	77.3	49.5	50.5	41.9	33.9
Reactor safety research (advanced reactors)	5.4	5.6	5.2	5.4	5.1	14.6
Reactor safety research (other and generic activities)	55.2	60.2	67.1	68.2	80.6	78.4
Nuclear energy risk sharing	–	–	–	–	50.0	142.0
Subtotal without national research centres	1 135.8	1 142.7	701.2	416.2	422.0	469.1
National research centres	443.2	411.8	376.2	343.5	348.5	323.7
Subtotal of the promotion priority	1 579.0	1 554.5	1 077.4	759.4	770.5	792.8
Promotion priority (nuclear fusion research) National research centres	157.8	167.4	198.2	194.9	194.8	192.4
Subtotal of all priorities without national research centres	1 649.5	1 583.2	1 105.1	817.8	799.3	825.3
National research centres	638.6	611.5	611.0	570.2	577.7	551.4
Total expenditure	2 288.1	2 194.7	1 716.1	1 388.0	1 377.0	1 376.7

Source: Research and Technology Ministry, January 1990

Source: Wagner, H. F. "The Third Energy R&D Programme of West Germany," Energy Policy, 19, May 1991, 397.

The third energy R&D programme of West Germany

Planned expenditure on energy research 1990–93.

Activity as part of the Federal Ministry for Research and Technology statement of present and future R&D projects	Current financial planning 1990	1991	1992	1993
Promotion priority				
Coal and other fossil energy sources				
without national research centres	136.0	129.0	122.0	121.7
national research centres	9.2	10.0	10.1	10.2
Subtotal	145.2	139.0	132.1	131.9
Renewable energy sources and energy conservation				
without national research centres	265.0	267.0	275.0	283.0
national research centres	29.3	28.0	30.0	32.0
Subtotal	294.3	295.0	305.0	315.0
Nuclear energy research (including reactor safety)				
without national research centres	302.7[a]	356.7	363.1	346.5
national research centres	303.6	303.9	297.0	306.1
Subtotal	606.3	660.6	660.1	652.6
Nuclear fusion research (national research centres)	195.8	198.9	198.3	206.8
Total				
without national research centres	703.7	752.7	760.1	751.2
national research centres	537.9	540.8	535.4	555.1
Total expenditure	1 241.6	1 293.5	1 295.5	1 306.3

Source: Research and Technology Ministry, 16 January 1990

Notes: [a]Plus up to DM 80 million in revenues from uranium sales.
[b]Information on EURATOM expenditure on fusion energy (ECU million): (1984) 149.1; (1985) 151.8; (1986) 147.1; (1987) 164.6; (1988) 155.3; (1989) 209.4; (1990) 217.8.

Source: Wagner, H. F. "The Third Energy R&D Programme of West Germany," <u>Energy Policy</u>, 19, May 1991, 398.

European joint R&D efforts in electronics

	Materials	SME and ATE[1]	Components	Computer equipment	Business equipment	Software	Telecommunications equipment	Consumer electronics	Instruments	Telecommunications services	Data-processing services	Other high-technology services
Brite/Euram (industrial technology/materials), 1989 on	●	●	●									
Joint optoelectronics research scheme, UK, 1982 on	●	●	●	●	●							
Alvey (electronics, information), UK, 1983–88		●	●	●	●	●	●	●	●			
Mega project (memory chip), West Germany and the Netherlands, 1983–89	●	●	●	●	●	●						
Distributed computing system, UK, 1984–86		●	●	●	●	●	●					
Esprit (information), Phase I, 1984–88	●	●	●	●	●	●	●	●	●	●	●	●
Eureka (market exploitation), 1985 on	●	●	●	●	●	●	●	●	●	●	●	●
Suprenum (supercomputer), West Germany, 1986–89				●	●	●	●	●				
Transputer (parallel processor), UK, 1987–91		●	●	●	●	●	●	●	●			
Link (precompetitive technology), UK, 1988–93	●	●	●	●								
RACE (communications), 1988–93	●	●	●	●	●	●	●	●	●			
Esprit, Phase II, 1989–94	●	●	●	●	●	●	●	●	●	●	●	●

Sources: Jacob Blackburn, U.S. Embassy, London; European Government documents; the European Community

1. Semiconductor manufacturing equipment and automatic testing equipment

Source: Kaplan, Gadi, and Alfred Rosenblatt. "The Expanding World of R&D," IEEE Spectrum, October 1990, 32.

Fourth Framework Program seeks $15.7 billion from 1994 to 1998

The EC's Parliament and Council of Ministers are expected to give the final okay to the Fourth Framework Program for Research & Technological Development by the end of the year. Few doubt that it will be changed much. Indeed, the European Parliament, which will begin debating the plan later this summer, is expected to ask for even more money than the 13.1 billion European Currency Units (ECU) ($15.7 billion) the European Commission is requesting. The program was approved by the European Council, composed of the prime ministers of the 12 countries, when they met for their semiannual summit meeting last month in Copenhagen.

The general outline for the program, which officially begins in early 1994, is the product of two years' study, discussion, and assessment of how well current Third Framework Program activities had been functioning.

BASIC RATIONALE

- Europe's research community is currently fragmented and lacks coherence. The research policies of the 12 separate countries often either overlap too much or work against one another. At the same time, European science is also underfunded. An EC framework approach has the advantage of viewing Europe's research system from above, as it were, and should be able to fill knowledge gaps where necessary, add funds to supplement important areas, continue to stimulate research cooperation across borders, and—most important of all—connect research results to technological developments for Europe's industries to help them compete globally.

COST

- ECU 13.1 billion—or $15.7 billion—over five years. The figure represents about 4% of the total research and technology budgets of the 12 countries.

CHANGES FROM THIRD FRAMEWORK PROGRAM

- Sharper focus on linking research to industrial problems.
- More support for industrial and biological technologies.
- Higher priority to solving social and rural problems.
- New research program in transportation systems.
- More importance to education and training.
- Stronger coordination of research in Europe's laboratories.
- More international cooperation in research and technology.
- Stronger focus toward Russia, other republics in the Commonwealth of Independent States, Eastern Europe.
- Stronger policy role for EC's Joint Research Center.
- More deliberate links between research and social needs.
- Coordination with Europe's other multinational R&D efforts.
- More focus on less developed regions of Europe.
- Much stronger technology transfer efforts.
- New priority of assessing effectiveness of technologies.

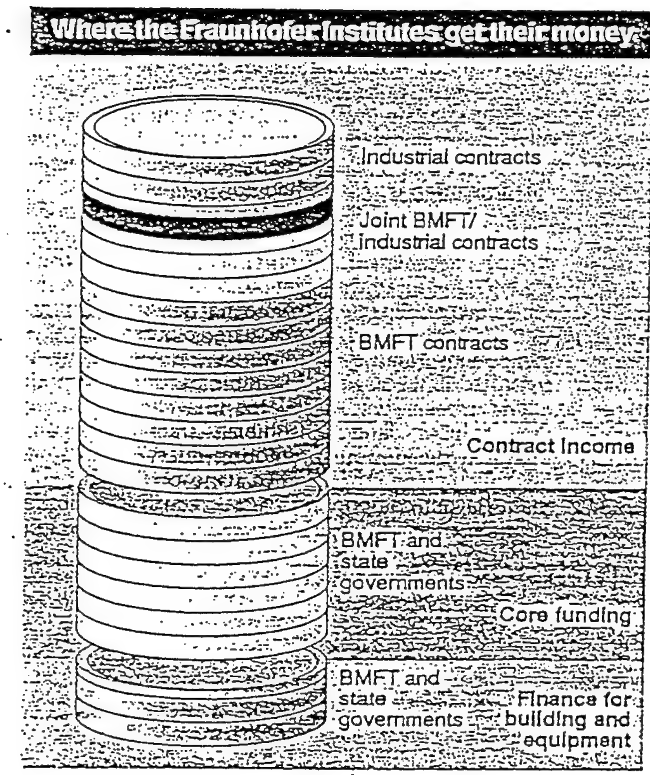
MAJOR PROGRAMS

- Research and technology ($13.1 billion).
- Information and communication technologies ($4.7 billion).
  - Data communication technologies supporting local and institutional needs
  - Technologies that integrate information and communication systems
  - Technologies for advanced communication services
  - Information technologies
- Energy ($3.0 billion).
  - Clean technologies
  - Nuclear safety
  - Controlled thermonuclear fusion
- Industrial technologies and materials ($2.1 billion).
  - Development of new technologies emphasizing design, systems approaches to production, and more effective roles for workers in production
  - Materials, materials processing, and recycling technologies
  - Advanced propulsion systems
  - Research in standards, measurement, and testing
- Life sciences and technologies ($1.6 billion).
  - General biotechnology
  - Biomedicine, health, and drugs
  - Application to agriculture, forestry, rural development, agro-industry, and fisheries
- Environment ($1.2 billion).
  - Natural environment, environmental quality, and global change
  - Innovative environmental protection technologies
- Transport policy research ($333 million).
  - Various urban, rail, air topics
  - Integration of systems
- Targeted socioeconomic research ($130 million).
  - Research into social integration problems
  - Research on education and training
  - Evaluation of science and technology policy options

OTHER AREAS OF ACTIVITY

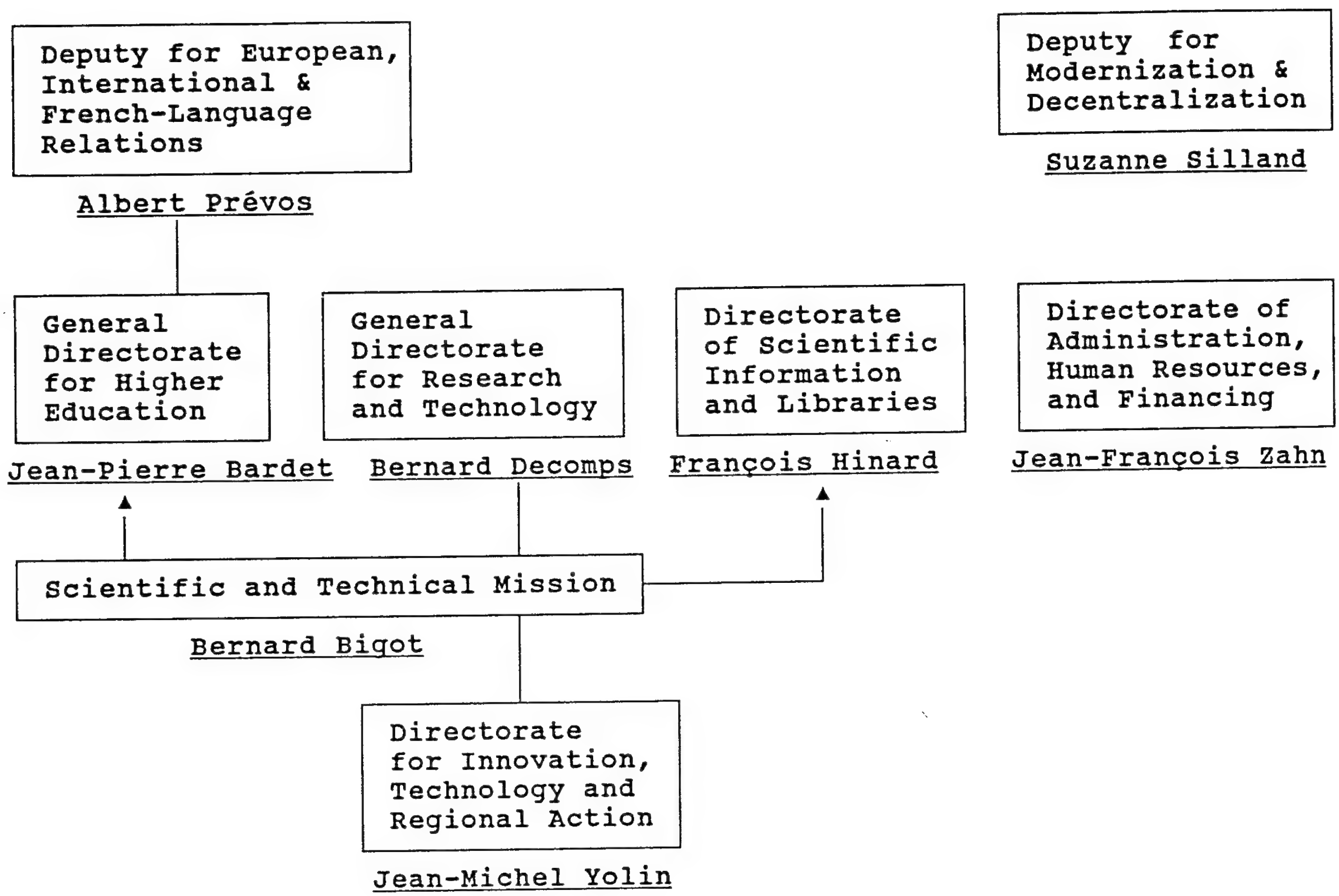
- International cooperation ($933 million).
- Technology transfer ($733 million).
- Research cooperation and training ($933 million).

Source: Lepkowski, Wil. "European Community Takes Bold New Steps in Science and Technology Policy," Chemical & Engineering News, 71, July 19, 1993, 13.



Source: Bown, William. "German Innovation, British Imitation," New Scientist [London], 4, No. 7, July 1991, 13.

French Ministry for Higher Education and Research, 1993



Source: La Recherche, 24, No. 257, September 1993, 1008.

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FRENCH PUBLIC RESEARCH AGENCIES

MESR	Ministry of Higher Education and Research
	(Has general oversight over civil research by most major public research organizations/agencies and universities):
AFME	French Agency for Oversight on Energy 1994 Budget: FF300 million
CEA	Atomic Energy Commission 1994 Budget: FF6500 million; Staff: 14,500+
CEMAGREF	National Center for Agricultural Mechanization, Rural Engineering, Waters, and Forests 1994 Budget: FF140 million
CESTA	Center for Study of Advanced Systems and Technologies (organizes seminars and colloquia on topical fields) Staff: 70
CIRAD	Center for International Cooperation in Agronomic Research for Development
CNES	National Center for Space Studies
CNRS	National Center for Scientific Research Staff: 10,700 researchers & 15,000 tech. and admin.
IFREMER	French Institute of Research for the Exploitation of the Sea 1994 Budget: FF820 million; Staff: 1,100
INED	National Institute of Demographic Studies 1994 Budget: FF50 million; Staff: 150
INRETS	National Institute of Research on Transport and Safety 1994 Budget: FF147 million; Staff: 180 scientists, total: 380
OTHERS:	Curie Institute (Biology Section), Pasteur Institute of Paris, Pasteur Institutes d'Outre Mer (Overseas), Pasteur Institute of Lille.
INSERM	Institute of Health and Medical Research 1994 Budget: FF1556 million; Staff: 1,800 researchers, total: 4,000

OTHER MINISTRIES' RESEARCH AGENCIES:

Six: Prime Minister's Planning Office, Ministry of Justice, Ministry of Culture and Communication, Ministry of Foreign Affairs, Ministry of Interior, and MILATT (Ministry of urban life and housing)

[Source: Kellerman, E. Walter. Science and Technology in France and Belgium. London: Longman, 1988, 19-32.]

FRENCH GOVERNMENT SCIENCE RESEARCH POLICY-MAKERS

Brezin, Edouard--President, CNRS

Borde, Jacques--CNRS representative to the UK

Curien, Hubert--Minister for Science and Technology; President of Eureka

Dautray, Robert--High commissioner of the Commission à l'Energie Atomique. Chairman of working group (9/93) set up for defining an agenda for a national debate on science and its relationship with education, industry, the economy, and society as a whole

Fillon, François--Minister of Higher Education and Research

Chesnais, François--OECD Directorate for Science Technology and Industry

Kourilsky, François--Director-general of CNRS

Lacombe, Jean-Louis--Technical Director of Matra-Marconi Space, Paris

Mariani, Jean-François--General manager of the International Division of Thomson-CSF, Paris

Pandolfi, Filippo Maria--EC vice-president for R&D

Praderie, François--Scientific head, Megascience Forum, OECD, Paris

Rouvillois, Philippe--CEA General Administrator

[Compiled from various sources]

FRENCH GOVERNMENT SCIENCE RESEARCH ORGANIZATIONS:

ANVAR	National Association for the Validation (Valorisation) of Research
ANDRA	Nuclear waste management agency
CEA	Commissariat à l'Energie Atomique--Atomic Energy Commission
CNRS	Centre Nationale de la Recherche scientifique--National Center for Science Research
EdF	Electricité de France--monopoly for nuclear power exploitation
ESRF	European Synchrotron Radiation Facility--Europe's first multinational synchrotron radiation facility at Grenoble (Construction was started 1/90)
Eureka	Launched in 1985, initiated by France--an R&D initiative led by European industry
ILL	Institut Laue-Langevin--at Grenoble
JESSI	Joint European Submicron Silicon Initiative
MRE	Ministry of Research and Space
MRT	Ministry of Research and Technology
OPST	Office Parlementaire des Choix Scientifiques et Techniques
SFP	French Physical Society
TCE	Thomson Consumer Electronics
Thomson-CSF	defense electronics group; 60% gov't owned
GERUF	Groupe d'Etude pour la Renovation de l'Université française (Group to Study the Revival of the French University)

[Compiled from various sources.]

Gross domestic expenditure on R&D (GERD) in selected countries

Country	1981	1987	1988	1989	1990	1991 [1]
	– US $ million [2] –					
Federal Republic of Germany [3]	16,614	26,446	28,199	30,378	31,904	35,476
France	11,439	18,091	19,478	21,475	23,760	24,957
United Kingdom [4]	12,253	17,089	18,111	19,466	20,150	19,300
Italy	4,725	8,957	9,853	10,752	11,964	13,370
Japan [5]	25,351	47,094	52,371	59,344	66,965	71,994
USA [6]	73,692	127,855	136,358	143,603	149,225	154,348
Canada [7]	3,558	5,962	6,353	6,702	7,199	7,496
	– % of GDP [8] –					
Federal Republic of Germany [3]	2.43	2.88	2.86	2.88	2.77	2.66
France	1.97	2.27	2.28	2.34	2.42	2.42
United Kingdom [4]	2.41	2.25	2.21	2.24	2.21	2.1
Italy	0.87	1.19	1.22	1.24	1.30	1.38
Japan [5]	2.32	2.82	2.86	2.98	3.07	3.04
USA [6]	2.45	2.87	2.84	2.80	2.77	2.78
Canada [7]	1.23	1.40	1.38	1.37	1.41	1.44

1) Provisional OECD data, based partly on national estimates, partly on OECD estimates.
2) Nominal expenditure, converted into US $ purchasing power parities.
3) Data for even years estimated; 1990 and 1991 revised estimates; 1987 break in series; up to and including 1990 former West Germany, 1991 Germany as a whole.
4) 1991 data provided by Central Statistical Office, London (March 31, 1993).
5) R&D expenditure overestimated.
6) Excludes most or all capital expenditure.
7) Provisional data for 1990.
8) GDP: Gross domestic product.

Source: OECD (1992/2) and BMFT calculations

Rounding error

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 108.

Country	1981	1987	1988	1989	1990
Federal Republic of Germany [2])	269	433	459	490	505
France	211	325	349	382	421
United Kingdom	217	300	317	340	351
Italy	84	156	172	187	208
Japan [3])	216	386	427	482	542
USA [4])	320	524	554	577	593
Canada [5])	146	233	245	255	270

[1]) Nominal expenditure, converted into US $ purchasing power parities.
[2]) 1987 break in series; 1988 and 1990 data estimated (1990 revised estimate).
[3]) R&D expenditure overestimated.
[4]) Excludes most or all capital expenditure.
[5]) Provisional data for 1990.
Source: OECD (1992/2), Federal Statistical Office and BMFT calculations

Rounding error

Table II/24

Financing of gross domestic expenditure on R&D (GERD)
– in % –

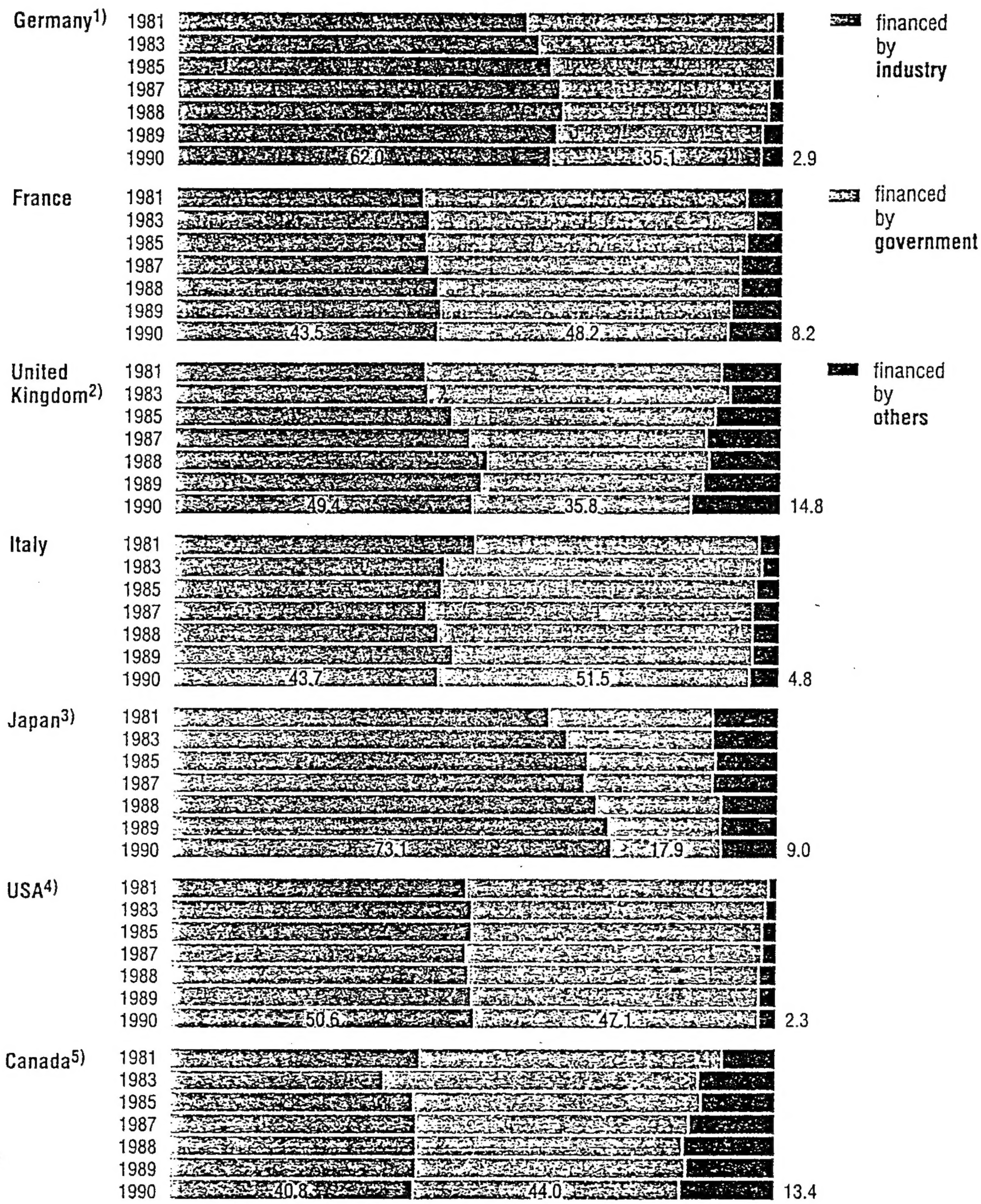
Country	financed											
	by industry				by government				by others			
	1981	1987	1989	1990	1981	1987	1989	1990	1981	1987	1989	1990
Federal Republic of Germany [1])	57.9	63.6	63.3	62.4	40.7	34.7	34.1	34.7	1.4	1.7	2.6	2.8
France	40.9	41.8	43.9	43.5	53.4	51.7	48.1	48.2	5.7	6.5	8.0	8.2
United Kingdom [2])	41.3	49.2	50.7	49.4	49.0	39.1	36.4	35.8	9.6	11.7	12.8	14.8
Italy	50.1	41.7	46.4	43.7	47.2	54.0	49.5	51.5	2.7	4.3	4.1	4.8
Japan [3])	62.3	68.5	72.3	73.1	26.9	21.5	18.6	17.9	10.8	10.1	9.1	9.0
USA [4])	48.8	49.0	50.2	50.6	49.3	49.1	47.6	47.1	1.9	1.9	2.2	2.3
Canada [5])	41.7	41.1	41.0	40.8	50.1	45.2	44.3	44.0	8.3	13.8	13.4	13.4

[1]) 1987 break in series, 1990 revised estimate.
[2]) 1986 break in series.
[3]) Contribution of industry underestimated.
[4]) Excludes most or all capital expenditure.
[5]) 1989 and 1990 unrevised breakdown not adding to the revised total. Provisional data for 1990.
Source: OECD (1992/2) and BMFT calculations

Rounding error

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 110.

in selected countries
– in % –



1) 1987 break in series. 1988 and 1990 revised estimates.
2) 1986 break in series.
3) Share of industry underestimated.
4) Underestimated: excludes most or all capital expenditure.
5) Provisional.

Source: OECD (1992/2) and BMFT calculations.

BMFT, BuFo '93

Source: Federal Ministry for Research and Technology, Report of the Federal Government on Research, 1993, Bonn: BMFT, July 1993, 111.